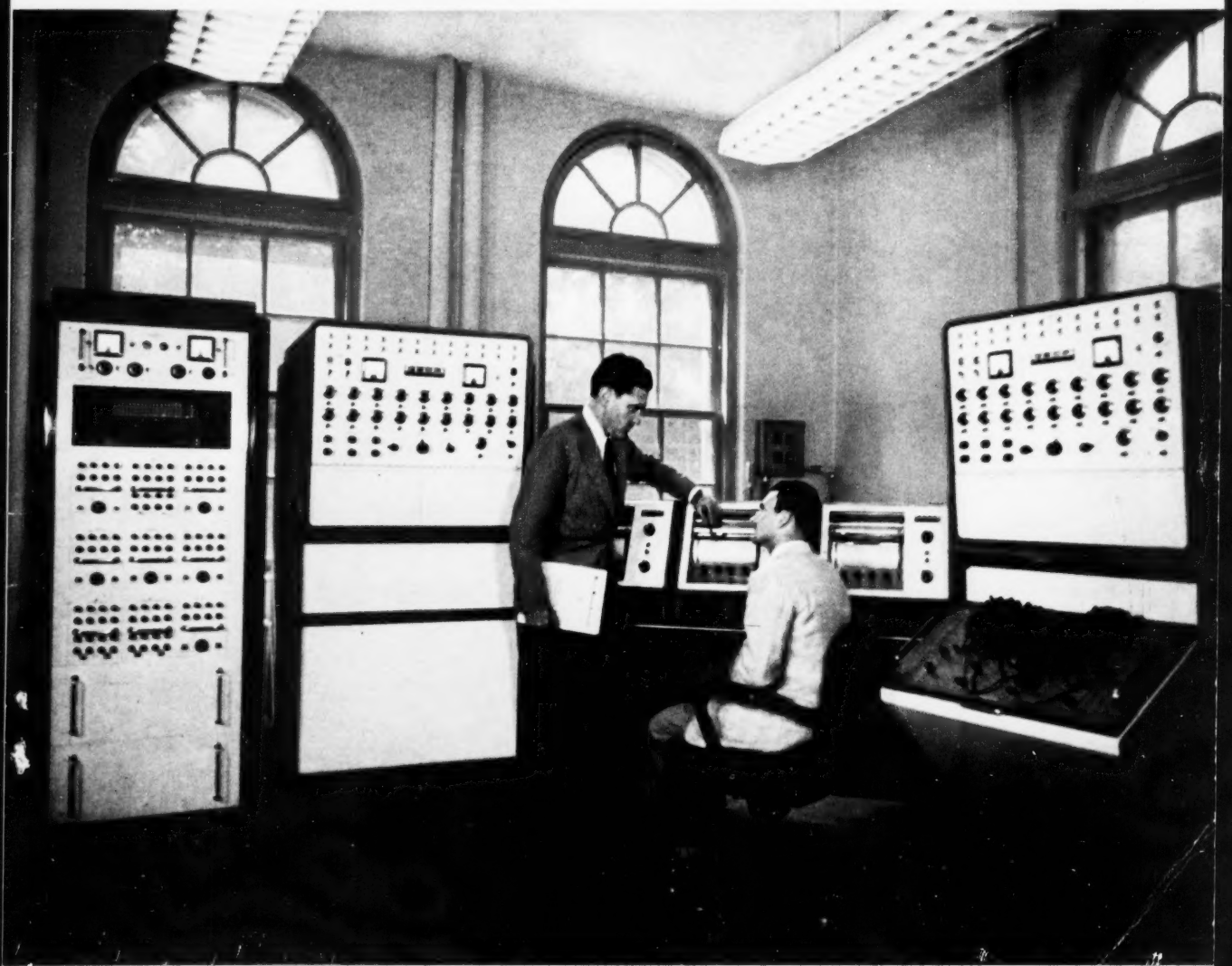
Instruments

THE MAGAZINE OF
MEASUREMENT · ANALYSIS · COMPUTING
INSPECTION · TESTING · CONTROL



GEDA Analog Computer Installation at Aberdeen Proving Ground, Md.
(Courtesy, Goodyear Aircraft Corp.) For story, see page 936.

Including the
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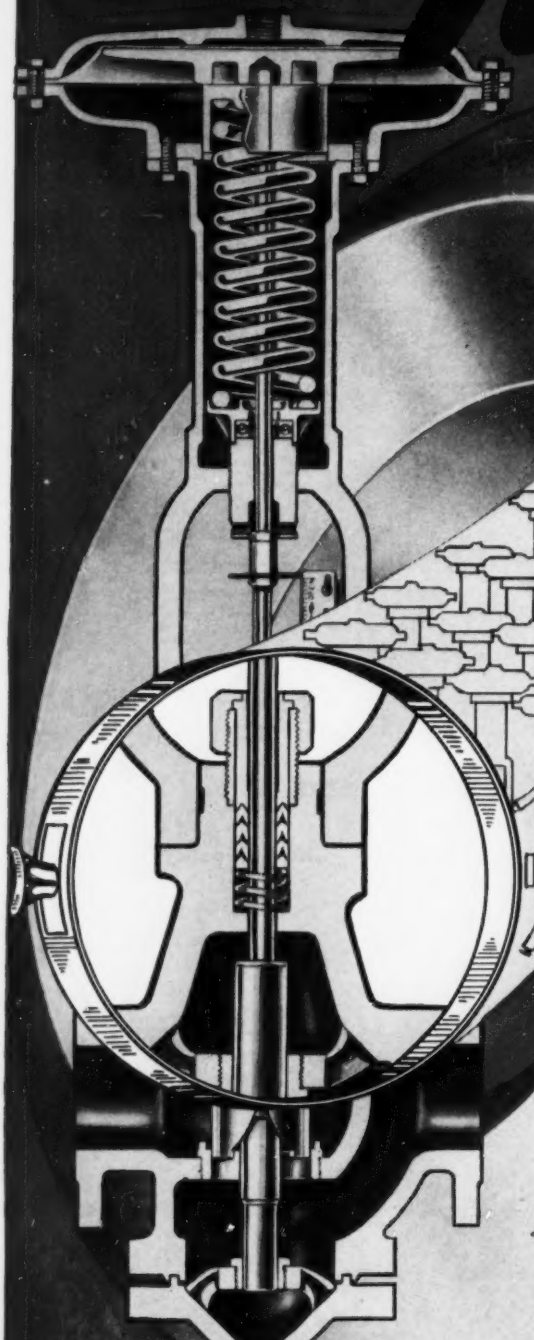
and the
JOURNAL OF THE SOUTHERN CALIFORNIA METER ASSOCIATION (Page 1035)

Vol. 26 No. 7
JULY • 1953

FISHER®

Teflon

V-RING PACKING



. . . LEADING THE MARCH TO BETTER DIAPHRAGM MOTOR VALVE PERFORMANCE

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- ***No gland leakage.***
- ***Used on wide range of pressures w out appreciable change in friction va***
- ***Elimination of maintenance and adjustment.***
- ***No valve stem lubricators re***
- ***Chemically inert to all flui up to 450° F.***

Fisher Teflon V-Ring Packing is now equipment on all Fisher Diaphragm Motor Valve

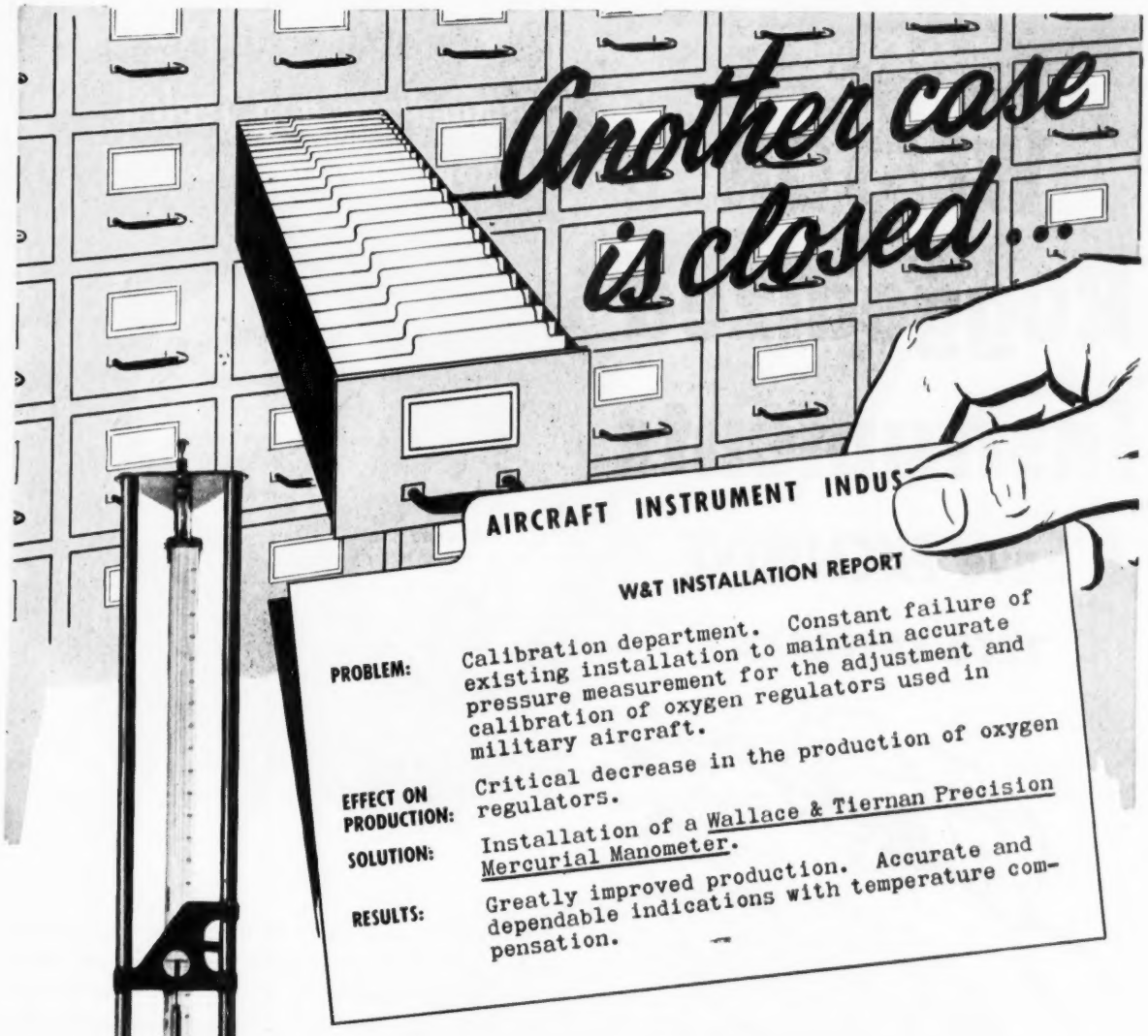
Bulletin E-200 give

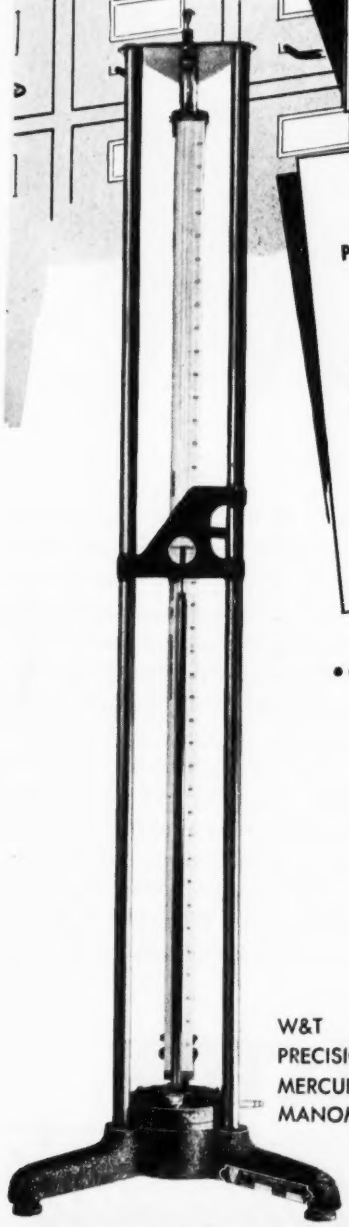
*Teflon is the trade name

FISHER GOVERNOR COMPANY

MARSHALLTOWN, IOWA

For more information circle 1 on inquiry card.


Another case is closed...
AIRCRAFT INSTRUMENT INDUS
W&T INSTALLATION REPORT
PROBLEM: Calibration department. Constant failure of existing installation to maintain accurate pressure measurement for the adjustment and calibration of oxygen regulators used in military aircraft.
EFFECT ON PRODUCTION: Critical decrease in the production of oxygen regulators.
SOLUTION: Installation of a Wallace & Tiernan Precision Mercurial Manometer.
RESULTS: Greatly improved production. Accurate and dependable indications with temperature compensation.



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FEATURES:

- **Scales are made with a precision dividing machine**
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- **Float type indicator eliminates difficulty in reading meniscus**
- **Mercury-sealed valve permits evacuating the tube easily and quickly**

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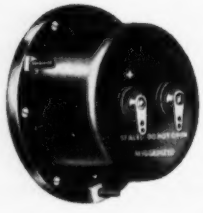
A-92

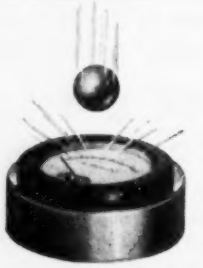
For more information circle 2 on inquiry card.

WESTON Ruggedized Instruments have *EXCLUSIVE* zero correctors



Connection terminals molded into internal rubber increase current carrying capacity.

No desirable instrument features were sacrificed in order to produce these truly ruggedized and effectively sealed instruments. With typical WESTON thoroughness, every feature has been retained including even the zero corrector. And *true* ruggedness has been achieved by new but thoroughly proved design concepts, such as shock-resistant spring backed jewels . . . flat windows of tough, anti-static, and glare reducing plastic . . . new high-strength tubular pointers, and a method of shock mounting and sealing that assures accurate indications under extremes of shock, vibration, temperatures, humidity, and downright abuse. Available in 2½" and 3½" D-C, R-F, A-C movable iron and rectifier types. WESTON Electrical Instrument Corporation, 614 Frelinghuysen Avenue, Newark 5, New Jersey.

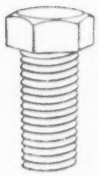


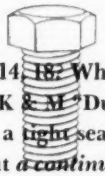
Tough, flat plastic windows reduce glare and are *really* shock resistant.

WESTON *Instruments*

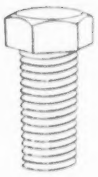
For more information circle 3 on inquiry card.

How many bolts are required for a perfect seal?

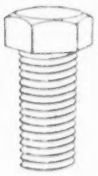




Should it be 10, 14, 18? Where do you stop?
In the patented K & M "Duoseal" design, just two bolts are required.
And you obtain a tight seal . . . not at 10, 14 or 18 points on
the casing . . . but *a continuous seal at infinite points throughout the entire perimeter.* The result: A completely tight, leakproof
seal that actually grows tighter as control pressure increases.
Furthermore, K & M "Duoseal" saves maintenance time with only two bolts
to tighten. This time saving is a particular consideration
when valves *must* be serviced or inspected in the line.
Within the drawn steel diaphragm casing, the K & M molded neoprene
diaphragm provides an extremely large effective area
that is constant throughout the long stem travel. Virtually the highest
"power factor" available results, with more sensitive response
to control pressure variations, more accurate inner valve positioning and
improved flow regulation through the K & M valve body.



***For Complete* Automatic Control Valve Data: Write for your copy of the new K & M Valve Engineering Data Catalog, Bulletin CV53. *Also, Available...* New Valve Size Calculator with Low Flow Data.**



diaphragm control valves

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64 Genung Street
Middletown, New York

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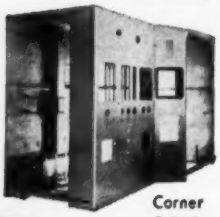
Benchboard Console

Five Section Cubicle Control Board and Lighting Canopy



Corner Cubicle Section

Refinery Cubicle with Mimic Flow Diagram in Color

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Experienced designing and quality fabrication assure the efficiency of any indicating, recording, or control installation. Whether you are planning new construction, modernizing existing installations or adding to present equipment, FALSTROM offers long years of experience and the most modern facilities for fabricating to your specifications or recommending standard designs. In any case, by specifying FALSTROM you specify the highest possible quality metal working techniques known to the industry. Estimates on your needs will be supplied promptly—call or write FALSTROM to arrange a consultation.

WRITE FOR BULLETIN #125

Visit our booth #214—1st floor at the Eighth National Instrument Exhibit—Hotel Sherman, Chicago, September 21-25, 1953

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92 Falstrom Court, Passaic, New Jersey
DESIGNERS, ENGINEERS AND BUILDERS OF CUSTOM METAL PRODUCTS FOR INDUSTRY

For more information circle 5 on inquiry card.

Instruments

THE MAGAZINE OF MEASUREMENT INSPECTION · TESTING · CONTROL

Vol. 26 July 1953 No. 7

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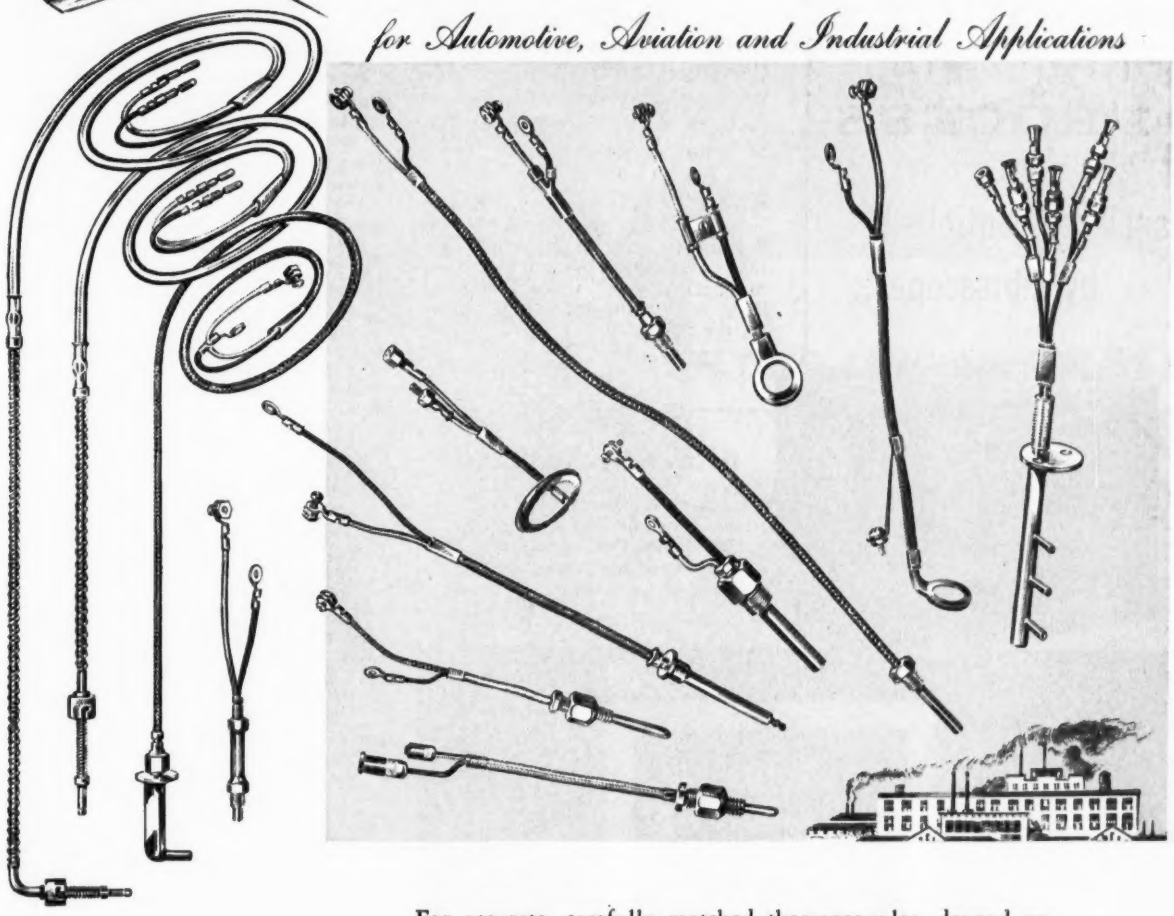
THERMOCOUPLES

IRON – CONSTANTAN
COPPER – CONSTANTAN
CHROMEL – ALUMEL
PLATINUM – PLATINUM-RHODIUM

for Automotive, Aviation and Industrial Applications



For accurate, carefully matched thermocouples, depend on *Lewis* experience to insure satisfactory performance and long service life. Illustrated above are a few of the many styles manufactured, from the bayonet cylinder-head type for aircraft reciprocating engines to the specialized designs for gas turbines.

LEWIS

Use *Lewis* thermocouples, *Lewis* lead-wire and *Lewis* Thermocouple Thermometers for exacting requirements of Aircraft, Automotive and Industrial installations.

THE LEWIS ENGINEERING CO.
Manufacturers of Complete Temperature Measuring Systems for Aircraft
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For more information circle 6 on inquiry card.

PLANT...

PRODUCT...

PROCESS

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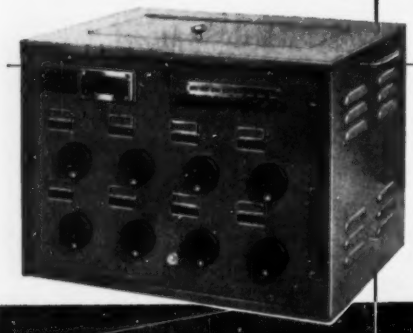
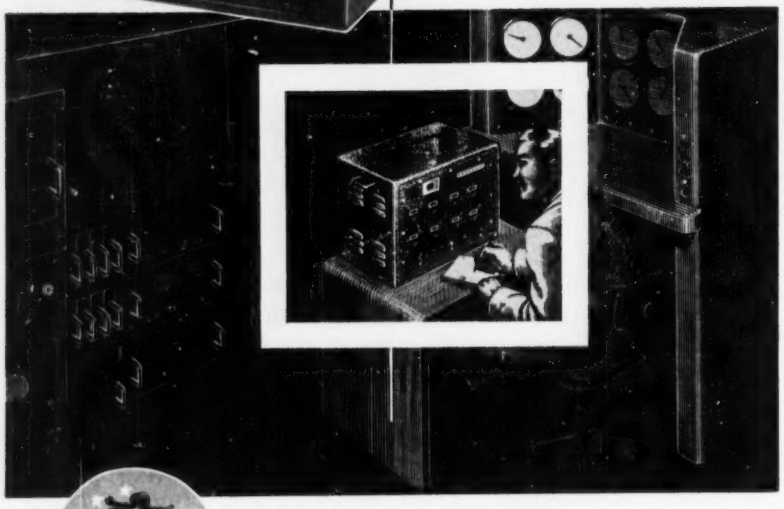
Whatever the function, Librascope *simplified* Computers and Controls are introducing new efficiency . . . in plant, product and process control of continuous or batch production. *Whatever your specific need . . .* Librascope, Inc., designers and manufacturers of both Analog and Digital Computers and Controls, can give you functionally designed equipment packaged to give the utmost in reliability and performance.

Whatever your problem-solving background in engineering or physics, if you are experienced in computers, instrumentation, circuitry, and/or magnetic devices, you will want to know more about Librascope's plans for the future.



The Simultaneous Equation Solver,

an *integral* part of Baird Associates, Inc. new spectograph, is a *simplified* analog computer that resolves the machine's complex data output.



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Instruments

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COVER STORY

Part of the Goodyear electronic differential analyzer (GEDA*) installation at the Ballistics Research Laboratory at Aberdeen Proving Ground. This analog computer is used in the simulation of missile trajectories, as a testing ground for new theoretical considerations of projectile behavior, and as a simulator for the various problems of exterior ballistics. It is the first large electronic analog computer to be installed at Aberdeen, which has long been the stronghold of extensive digital computers. Computing units shown include two linear computers, one electronic non-linear computer, and three automatic curve-followers. Units not shown include two continuous-chart 6-channel read-out tables and a bank of servo-multipliers and resolvers.

*GEDA, T. M., Goodyear Aircraft Corporation, Akron 15, Ohio.

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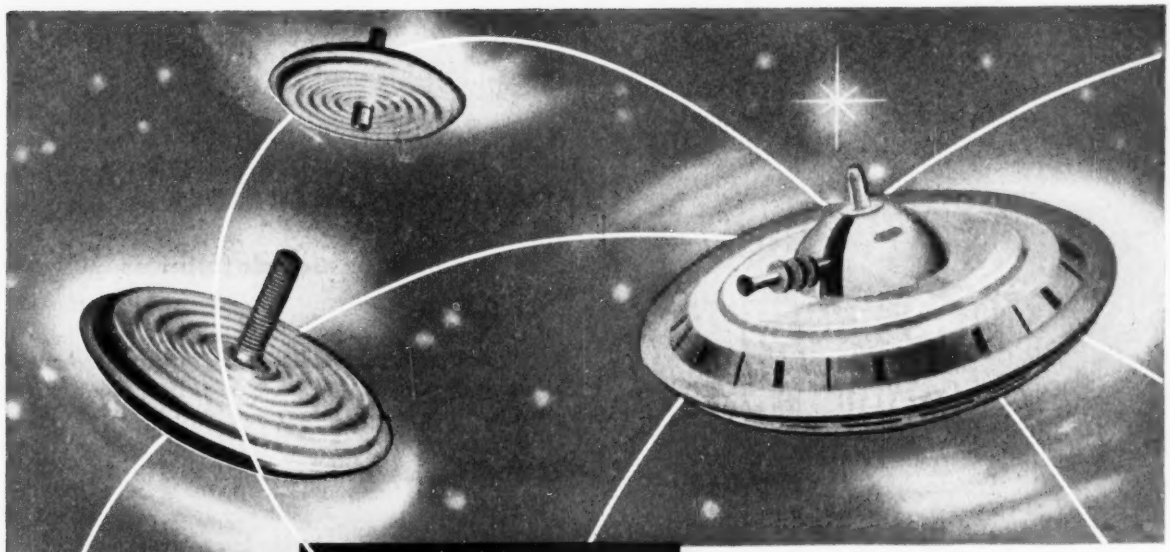

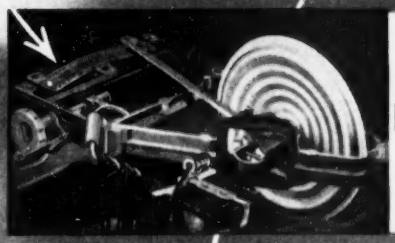

FLYING SAUCERS..REAL!

One type of instrument a weather balloon carries aloft is the radiosonde. This inexpensive little weather observer reports continuously—by radio—the temperature, pressure, and humidity of the upper air.

Key parts of radiosonde are temperature and humidity elements and a disc-shaped, pressure-responsive diaphragm that supplies the all-important pressure "reference".

U. S. Gauge makes radiosonde diaphragms to ± two-millibar accuracy from Ni-Span C—an alloy with a constant thermal modulus—to cancel temperature effects. Compensating thermal influence of the instrument components within the diaphragm design was another—and tough—problem. USG licked it—hopes to tackle one for you.

If you require diaphragms like those we've described . . . if you have any product in need of accurate temperature or pressure-sensing elements or instruments, let USG creative instrumentation go to work for you. United States Gauge, Division of American Machine and Metals, Inc., Sellersville, Pa.

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Creative Instrumentation UNITED STATES GAUGE **USG**

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A guide for selecting temperature control for top furnace performance

Today, industry's need *for lower operating costs . . . reduced maintenance . . . high quality of production . . . has spot-lighted the importance of "tight" furnace control.*

With closer specifications and higher control standards, more and more plants must pin down troublesome, costly departures from favorable heat-treating conditions.

To meet this demand, Leeds and Northrup has a complete line of matched temperature control systems available. You get equipment matched to your particular requirements.

Each system comes to you as a "package" ready to handle the individual conditions created by your product, your production and your furnace.

TWO-POSITION CONTROL

For fuel-fired or electric furnaces

What it does:

Cuts heat input back to "low" when temperature exceeds control point . . . turns heat input on full when it falls below control point.

When to use it:

1. When changes in heat supply or changes in load are promptly "felt" by the temperature detector.

2. When alternate undershoot and overshoot will not damage product or process equipment, or slow down production.

3. When furnace pressure or fuel-air ratio *are not* controlled and the products of combustion *do not* form a protective atmosphere for the work.

PROPORTIONING-TYPE CONTROL

For fuel-fired furnaces

What it does:

Adjusts heat input by varying valve opening according to size of temperature change.

When to use it:

1. When there's a substantial time lag, before changes in heat supply or changes in load are "felt" by the temperature detector.

2. When load changes on continuous processes are both small and infrequent, and control point is rarely changed.

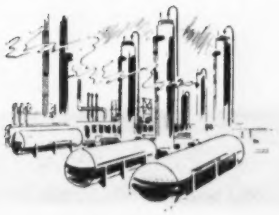
3. On batch process where operation is usually at the same temperature, and rapid recovery from upsets after loading is not important.

4. When furnace-pressure or fuel-air ratio *are* controlled, or the products of combustion *do* form a protective atmosphere for the work.

There's an L&N control

For more information circle 9 on inquiry card.

POSITION-ADJUSTING-TYPE CONTROL (P.A.T.)



Refining Towers

For fuel-fired furnaces

What it does:

Adjusts heat input by varying valve opening according to size, duration and speed of temperature changes.

When to use it:

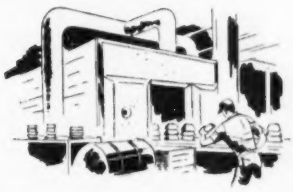
1. When there's a substantial time lag, before changes in heat supply or changes in load are "felt" by the temperature detector.

2. When load changes are both large and frequent and control point must be changed to suit various conditions.

3. When furnace design requires a continuously throttled flame.

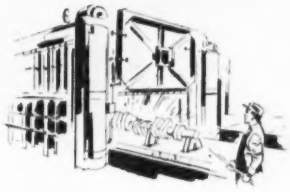
4. When furnace-pressure or fuel-air ratio *are* controlled, or the products of combustion *do* form a protective atmosphere for the work.

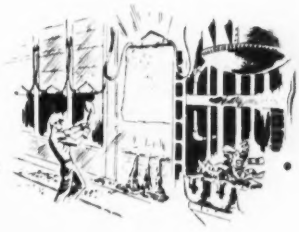
5. Whenever overshoot is costly, hazardous or can cause damage to the product or heating equipment.



Tunnel Kilns

Forging Furnaces





Open Hearths

DURATION-ADJUSTING-TYPE CONTROL (D.A.T.)

For fuel-fired or electric furnaces

What it does:

Adjusts heat input by varying length of "heat on" time according to size, duration and speed of temperature changes.

When to use it:

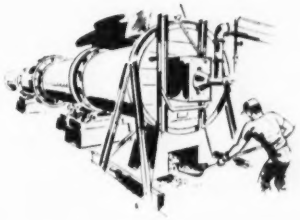
1. When there's a substantial time lag, before changes in heat supply or changes in load are "felt" by the temperature detector.

2. When load changes are both large and frequent, and control point must be changed to suit various conditions.

3. When furnace design requires use of "on-off" operation of heat supply.

4. When furnace-pressure or fuel-air ratio *are not* controlled, and the products of combustion *do not* form a protective atmosphere for the work.

5. Whenever overshoot is costly, hazardous or can cause damage to the product or heating equipment.



Rotary Kilns

Annealing furnaces

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to match every industrial furnace

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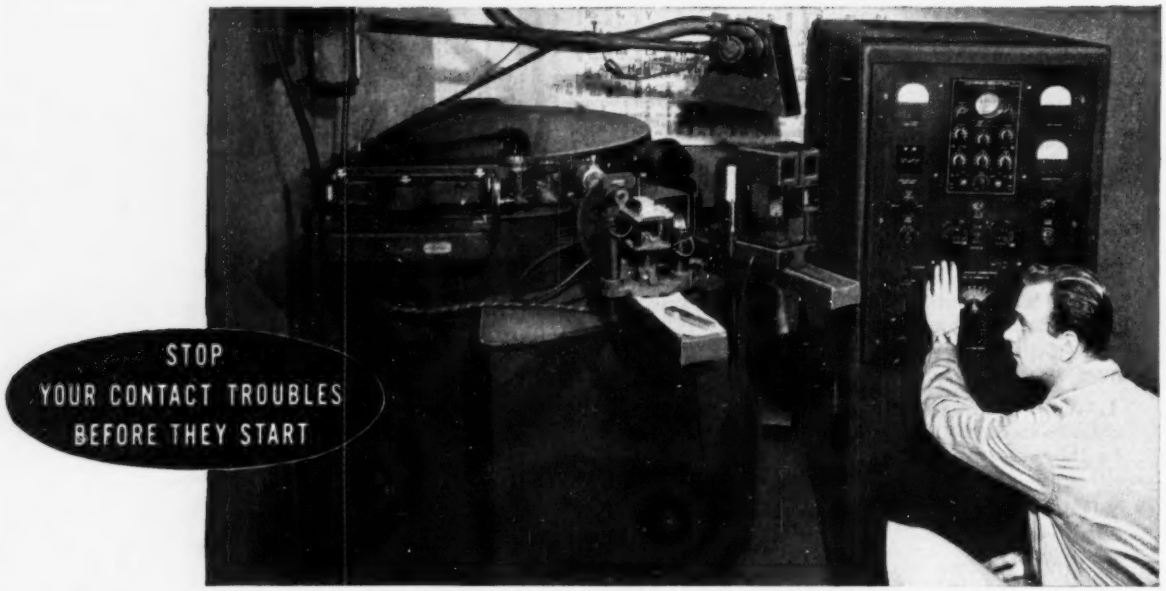


Spectrograph equipment in the Mallory Contact Engineering Laboratory for analyzing the composition of metals and alloys used in electrical contacts.

To A Concentration of .0001%

Mallory quality control includes spectrographic analysis of contact metals and alloys.

At Mallory, performance and long life for the contacts in your products start in the laboratory where a spectrograph and densitometer give fast accurate answers to the composition of metals and alloys.

This equipment is used regularly in production quality control as well as in new material development and trouble shooting. It is a positive means of identifying any contamination or impurity that might reduce contact efficiency.

Mallory is equipped with complete laboratory, engineering and production facilities to handle any contact requirement —from simple button or rivet contacts to complex contact assemblies.

Mallory engineers have had years of experience in the design and production of over 5000 different types of contacts and contact assemblies. We are ready for your call.

Expect more . . . Get more from **MALLORY**

In Canada, made and sold by Johnson Matthey and Mallory, Ltd., 110 Industry Street, Toronto 15, Ontario

Electrical Contacts and Contact Assemblies

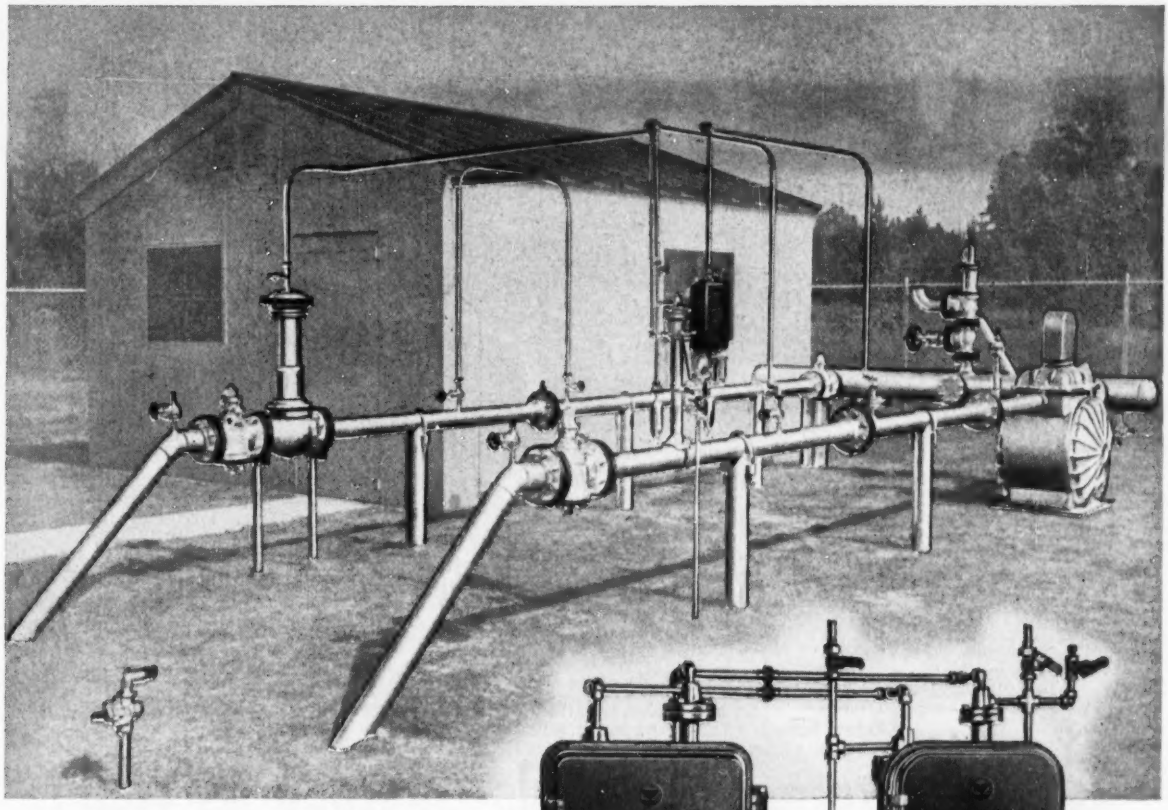
P.R.MALLORY & CO. Inc.
MALLORY

SERVING INDUSTRY WITH THESE PRODUCTS:
Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical—Capacitors • Rectifiers • Mercury Batteries
Metallurgical—Contacts • Special Metals and Ceramics • Welding Materials

P. R. MALLORY & CO. INC., INDIANAPOLIS 6, INDIANA

For more information circle **10** on inquiry card.

PRECISION GAS MEASUREMENT AT HIGH OR LOW FLOW RATES

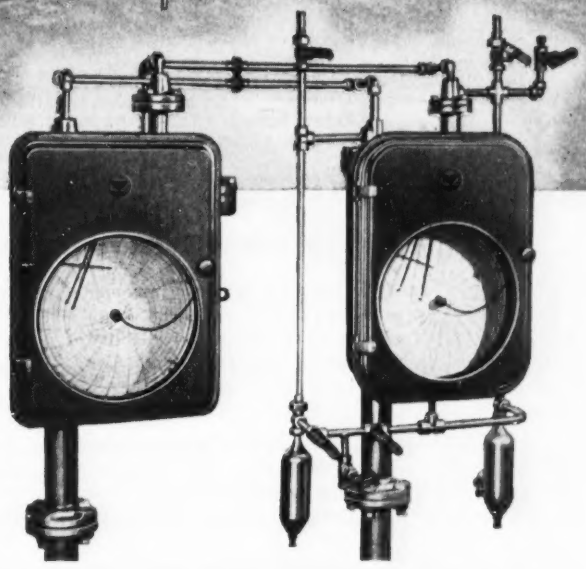


Southern Natural Gas Company Accurately Records Intermittent High and Low Volume Measurements.

Flow rates from zero to 154 thousand cubic feet of natural gas per hour are measured by this fully automatic measuring station.

An American® 500B, 250-pound Ironcase Displacement Meter measures flow rates up to 31,000 cubic feet per hour. Demand volume and meter pressure are recorded by a seven-day 100-pound American Volume and Pressure Gage.

A 100-inch Series A-88 American Differential Valve actuates a 4-inch Type CBVA Reliance Control Valve transferring approximately 80 percent of the flow to the orifice meter run when flow rates exceed the capacity of the Ironcase Meter.

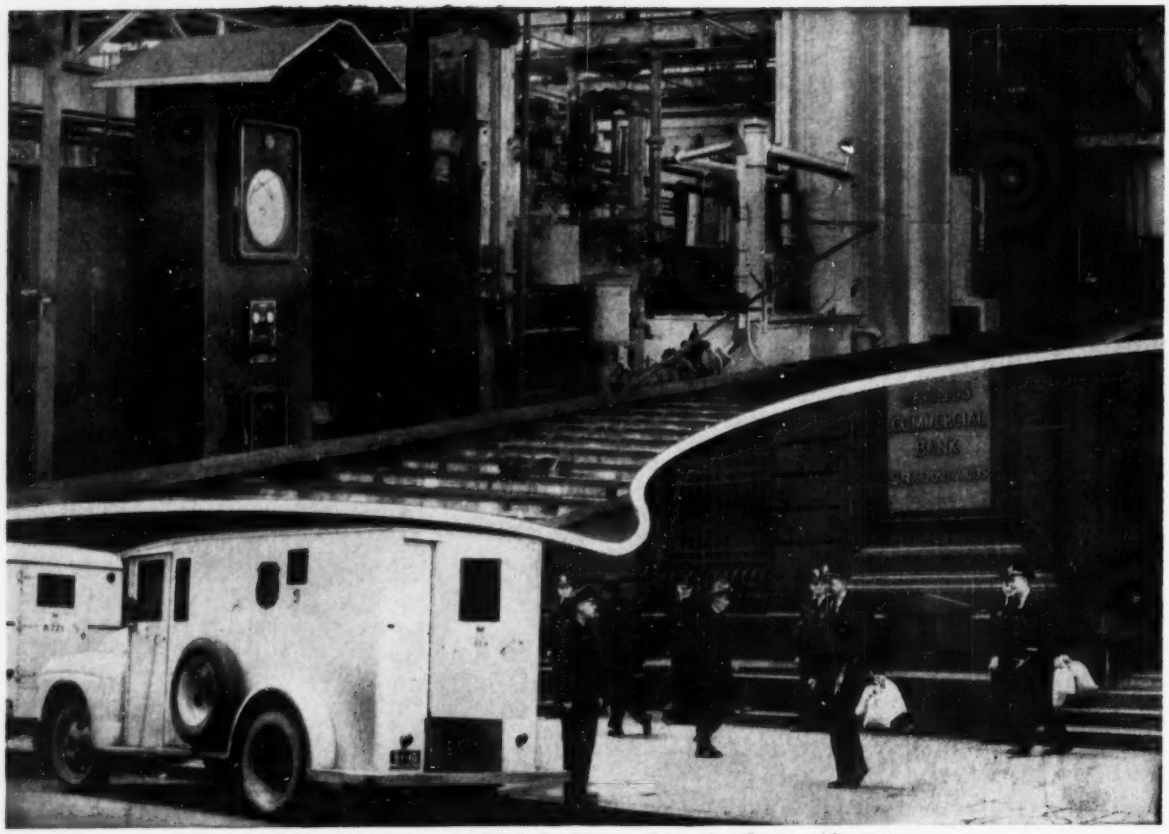


This Duplex installation consisting of 20-inch — 100-inch Series A-88 American Westcott Orifice Meters records 80 percent of the flow at rates from 31 thousand to 154 thousand cubic feet at normal operating pressures of 50 pounds gauge pressure in the orifice meter run when used in the above combination with the 500B Meter.

AMERICAN® METER COMPANY
INCORPORATED ESTABLISHED 1836

GENERAL SALES OFFICE: 1513 Race Street, Philadelphia
Albany • Alhambra • Atlanta • Baltimore • Birmingham
Boston • Chicago • Dallas • Denver • Erie • Houston
Kansas City • Los Angeles • Minneapolis • New York
Odessa • Omaha • Pittsburgh • Tulsa • San Francisco
IN CANADA: Canadian Meter Company, Limited
Hamilton, Ontario • Edmonton, Alberta

For more information circle 11 on inquiry card.



Modern Safeguards—Brink's for Money. Bailey for Process Materials

Are Your Process Materials Guarded As Well?

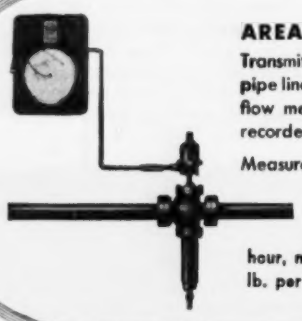
HERE'S HOW TO PREVENT SPOILAGE AND WASTE . . .

TO avoid waste of valuable process materials and finished products, process rates and conditions must be accurately measured and controlled. That's were Bailey Meters, Analyzers and Controllers can help you to improve the efficiency of your plant.

Take flow for instance. Bailey Meter Company offers a complete line of flow measuring and controlling equipment for applications ranging all the way from high pressure steam to low pressure gas. We measure flow in pipes, open channels, ducts, furnaces, smelters, kilns, ovens, dryers.

When you call Bailey Meter Company, you get the help of years of experience as well as recommendations from a wide selection of measuring and controlling devices.

Your local Bailey Engineer is as near as your telephone. He has the experience and the equipment necessary to set up an effective guard for your process materials.



AREA TYPE FLOW METER

Transmitter goes into 1, 2 or 4 inch pipe line like a valve and transmits flow measurements electrically to recorder in remote location.

Measures oil and other clear liquids under static pressures up to 600 psi. Minimum range 0 to 1200 lb. per hour, maximum range 0 to 96,000 lb. per hour.

BAILEY METER COMPANY

1041 IVANHOE ROAD
CLEVELAND 10, OHIO

Process Controls
TEMPERATURE · FLOW
PRESSURE · LEVEL
GAS ANALYSIS · RATIO

For more information circle 12 on inquiry card.

Circle 13 on inquiry card. ⟶

TAKE NO CHANCES WITH SLIGHT LEAKAGE

APPLICATION: Where even slight leakage of a flowing medium might become obnoxious, dangerous or excessively expensive.

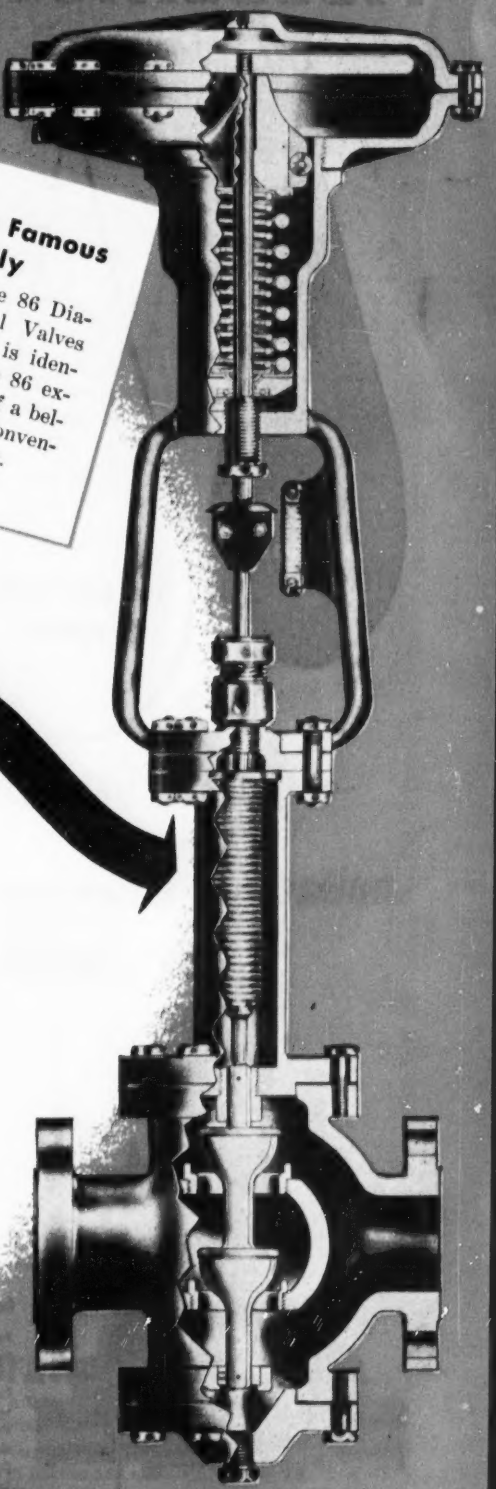
Specify

BS&B CLIMAX

Type 87 Diaphragm Control Valves

From The Famous Family

of Climax Type 86 Diaphragm Control Valves . . . the Type 87 is identical to the Type 86 except for the use of a bellows seal plus a conventional stuffing box.



. . . with bellows sealed stem

Climax Type 87 Diaphragm Control Valves were especially developed by BS&B for the oil, gas and chemical processing industries to provide a valve which is absolutely leak-proof. All Type 87 valve bodies are designed to conform to I. S. A. tentative face-to-face standards. Design features BS&B's interchangeability-of-parts advantage for greater operating and maintenance economy.

Type 87 is manufactured for all services and in all materials that are contemplated by Type 86, and in sizes from ½" to 6". Bellows can be supplied in bronze, stainless steel, Monel, Hastelloy "B", Nickel or other special alloys suitable. Maximum working pressure 400 lbs. cwp. The conventional teflon packed stuffing box is installed at the point the valve stem passes out of the bellows casing to forestall any appreciable loss of flowing medium in case of a bellows failure.

ASK YOUR BS&B MAN OR SALES REPRESENTATIVE . . . or write to Black, Sivalls & Bryson, a leader for over 60 years in oil and gas producing and refining equipment . . . manufacturer of the finest in controls and equipment for the processing industries . . . 54 Branches and Sales Offices in the United States and Canada.

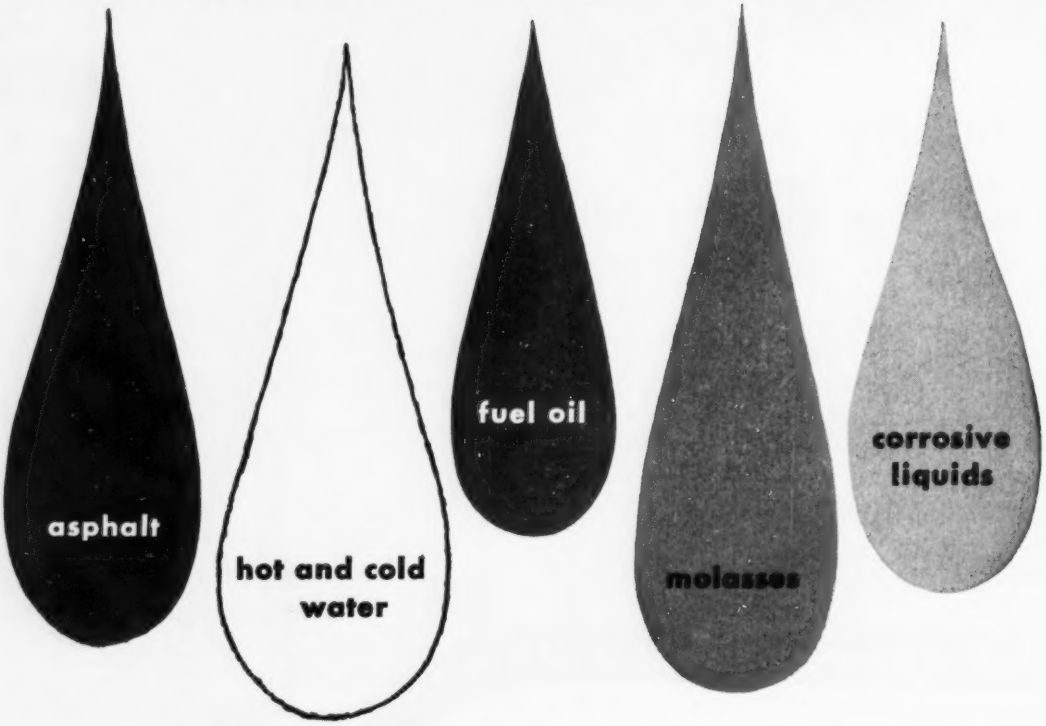
CLIMAX BS&B CONTROLS OVER 60 YEARS

BLACK, SIVALLS & BRYSON, INC.

Climax Controls Division, Dept. 4-V7

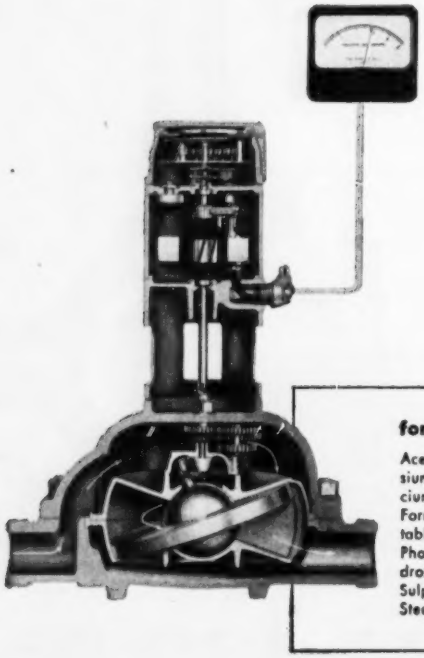
7500 East 12th St. Kansas City 26, Missouri

viscosities unlimited



HAYS VERIFLOW METER AND HAYS ELECTRONIC VERITROL

indicate and control liquid flow



Now virtually all fluids can be precisely measured and accurately controlled—*from a remote position.*

Hays VERIFLOW meter accurately measures, indicates, and totals the flow of corrosive and hard-to-meter liquids without using weigh tanks, orifice plates, or gage sticks.

With the Hays VERITROL you simply set a knob at the rate of flow desired . . . then, the VERITROL controls the flow of liquid at that set-rate.

Send for a complete description of Hays Veriflow Meter and Veritrol, Pub. No. 53-766-38.

for corrosive liquids

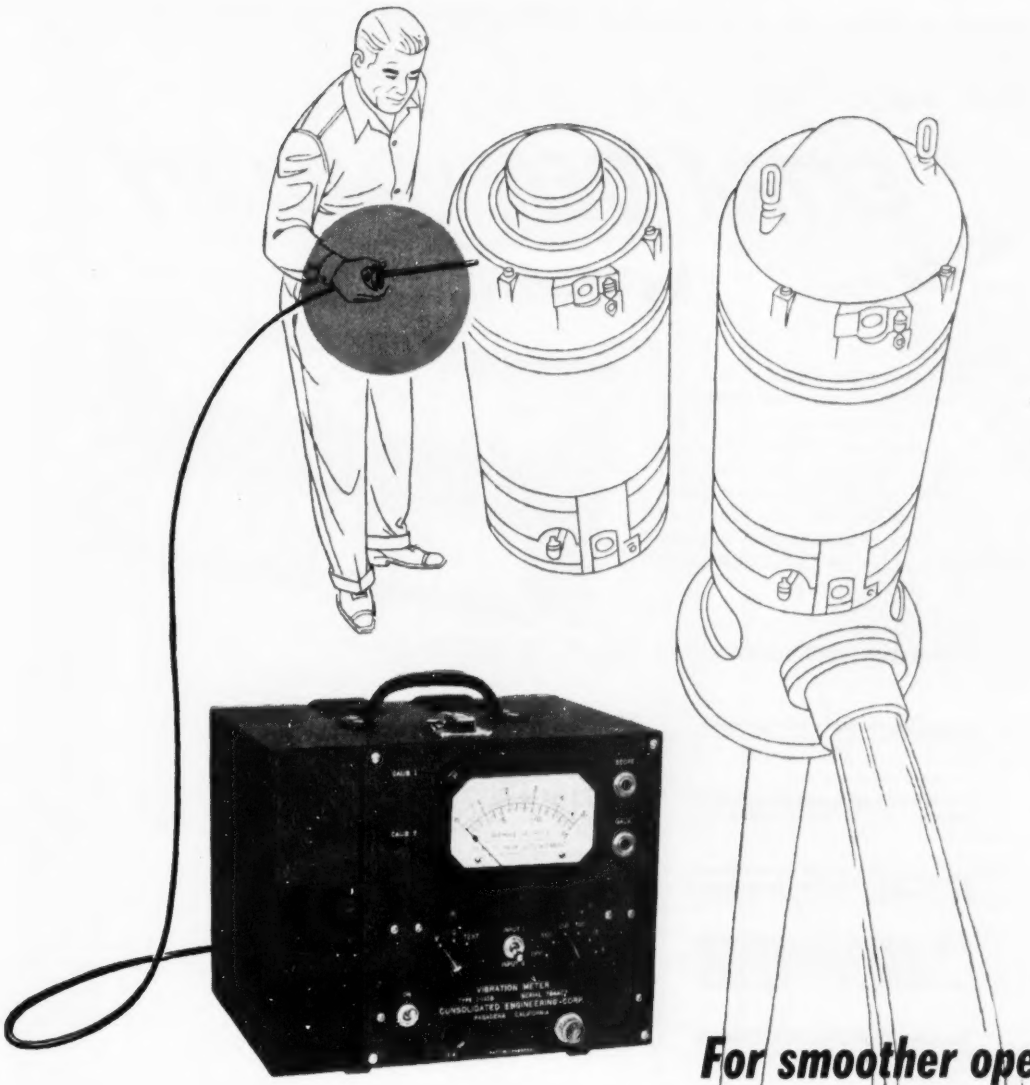
Acetic Acid, Aluminum Potassium Sulphate, Ammonia, Calcium Compounds, Carbolic Acid, Formaldehyde, Fruit and Vegetable Juices, Hydrogen Peroxide, Phosphoric Acid, Potassium Hydroxide, Sodium Compounds, Sulphuric Acid (concentrated), Stearic Acid, and many others.

Automatic Combustion Control
Boiler Panels • Hays-Penn Flowmeters
Veriflow Meters and Veritrol
Gas Analyzers • Draft Gages
Combustion Test Sets • CO_2 Recorders
Electronic Oxygen Recorders
Electronic Flowmeters
Electronic Feed Water Controls
Miniature Remote Indicators

THE hays CORPORATION

Michigan City 6, Indiana

For more information circle 14 on inquiry card.



For smoother operation and longer life

EVERY MOTOR at U. S. Electrical Motors, Inc., is checked for dynamic balance before being placed in service. Vibration elimination, important in all motors, is vital to the satisfactory performance of vertically mounted motors that drive deep-well pumps. Their high centers of gravity magnify and transmit any imbalance through long vertical shafts to submerged pumps. To prevent damage to motor, shaft and turbine impellers, every U. S. Verti-closed motor is pre-checked with Consolidated instrumentation. Vibration monitoring is a profitable practice, paying off in greater customer satisfaction. If vibration elimination would improve your process or your product, our long experience in the field of dynamic measurement can help you.

Consolidated Engineering
CORPORATION
300 North Sierra Madre Villa, Pasadena 15, California

Sales and Service through **CEC INSTRUMENTS, INC.,** *a subsidiary with offices in: Pasadena, New York, Chicago, Washington, D. C., Philadelphia, Dayton.*

analytical instruments for science and industry

Vibration Meter—and Vibration Pickup, a simple, effective dynamic measuring combination. Consolidated makes many types of transducers, amplifiers, bridge balances and recording oscillographs for use in science and industry. Write for CEC Bulletin **1505B-X9.**

For more information circle **15** on inquiry card.

Put your finger on

EXTRA DEPENDABILITY

by specifying...

CHESTER means dependability *plus* in wires and cables for every electronic and electrical application. The compounds used in all **CHESTER** Wire and Cable constructions are made in the CHESTER plant. Thus, complete control over selection of raw materials and manufacturing techniques, provides full control of quality... your assurance of uniformity in every foot of conductor bearing the CHESTER label!

CHESTER
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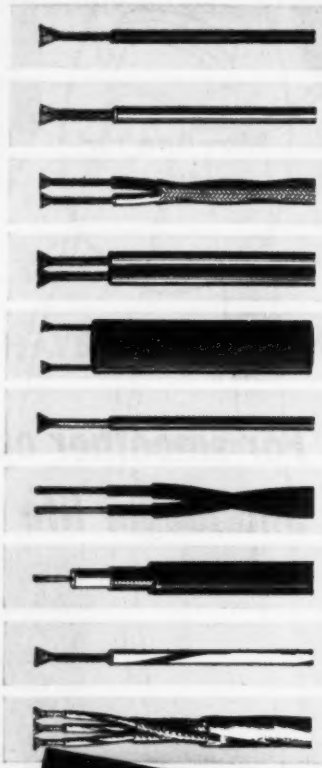
WIRES & CABLES



- JAN-C-76 WIRES* SRIR, SRHV, SRRF, WL
- 105°C, 90°C, 80°C, UL APPROVED; 120°C*
- SHIELDED WIRES & CABLES
- FLEXIBLE CORD
- TV LEAD-IN WIRES
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- COMMUNICATION WIRES & CABLES TO SPECIFICATION
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*Solid colors or spiral marking

CUSTOM CONSTRUCTIONS to specification using Polyethylene, Polyvinyl Chloride, Nylon, Braided and Lacquered Wires, Special Insulating Materials, Glass, Yarn, etc. Inquiries invited.

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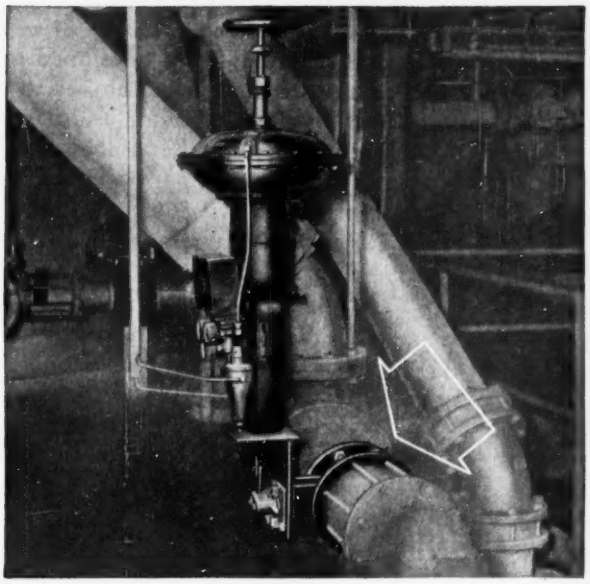
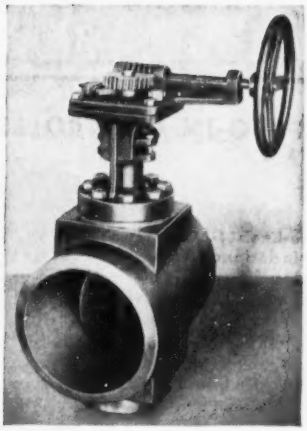
For more information circle 16 on inquiry card.

R-S valvEvents

• EXCERPTS FROM THE R-S BOOK OF EXPERIENCE •



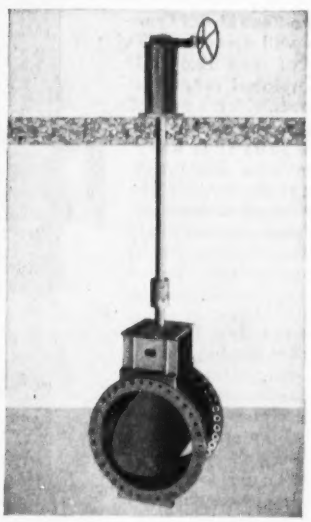


No. 677-A—1500-pound welding-end steel valve for superheated steam service. A. S. M. E. standards with heavy duty handwheel control.

R-S VALVE ADVANTAGES
Under Automatic Control

1. Wide range of throttling from open to closed position. 30 to 1 is standard. Minimum torque required for positioning.
2. Any type of instrument or control actuator can be used depending on preference and conditions. In any application, the R-S Valve usually costs less to purchase, less to install and results in lower pumping costs due to simplicity of design.
3. R-S Valve design offers no pockets to capture sediment, no change of flow-direction to create turbulence. Freedom from turbulence reduces erosion and cavitation and therefore adds to the life of the valve.

R-S Valves are used for regulation, pressure reduction, liquid level control, flow control, shut-off and other functional applications.



No. 864—50-pound valve equipped with rubber seat, extended shaft, thrust bearing, floor stand and heavy duty handwheel control.

Consult your local R-S Valve Engineers, or write direct.

R-S PRODUCTS CORPORATION • 4600 Germantown Ave., Philadelphia 44, Pa.

An S. Morgan Smith Company Subsidiary

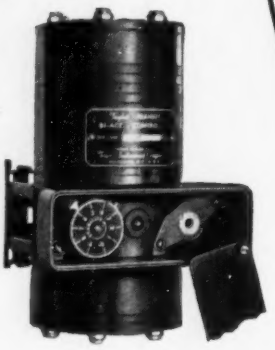
REPRESENTATIVES IN PRINCIPAL CITIES

For more information circle 17 on inquiry card.

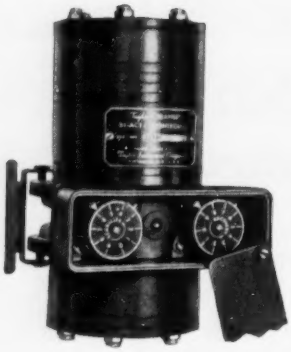
VERSATILITY

PLUG-IN CONTROLLERS

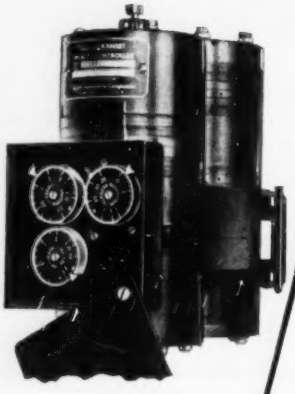
The One-Knob BI-ACT Controller is designed for use in industrial processes with short time lags, such as close-coupled liquid flow, fast pressure and comparable temperature problems. Combines simplicity of adjustment and economy.



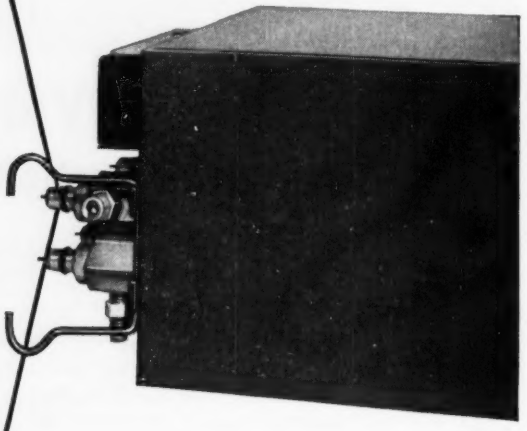
The Two-Knob BI-ACT Controller will cover the full range of reset rate and proportional response adjustments. This makes it more satisfactory for those jobs that have longer time lags, and where close response adjustments are essential to good performance.



The Brand New TRI-ACT Controller combines all 3 response adjustments (gain, reset rate and Pre-Act response). It is the most complete controller, giving the very best control on the more complex processes, particularly those with long time constants, and load changes requiring both derivative and reset adjustments. Gives faster recovery on load changes; start-up without overpeaking; the benefits of automatic reset without its evils.



And it's a versatility born of experience, proven sound and developed to a high point of efficiency. The key to this versatility is the Taylor Plug-In Feature, which enables the process engineer to quickly select or change both his controllers and receivers to meet control or processing requirements as they develop. He can use the One Knob or Two Knob BI-ACT* or TRI-ACT* Controllers, depending on the quality of control required or operating conditions encountered; he can switch, in seconds, from an indicating to a recording receiver, with or without automatic to manual features, or with cascade (pneu-



HERE'S WHAT *VERSATILITY* MEANS TO YOU!

1. You can plug in shop-adjusted instruments.

2. You can efficiently analyze process difficulties by quickly substituting a recorder for an indicator.

3. You can switch from the simplest to most complete controller in a matter of seconds.

4. Down time is kept to a minimum, since both controllers and receivers plug in.

5. Maintenance is unnecessary in the area of

TAYLOR INSTRUMENTS

For more information circle 18 on inquiry card.

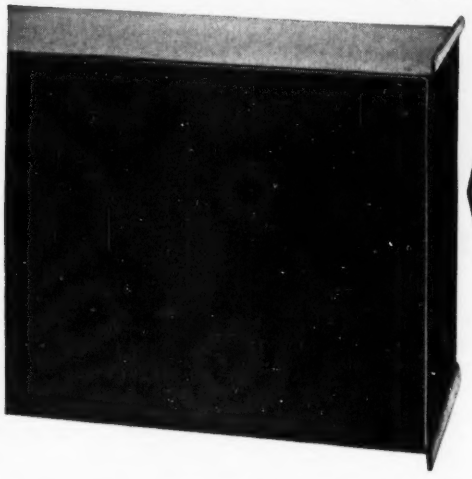
IS ONE WORD FOR THE TAYLOR TRANSET® SYSTEM!

matic set) features. In other words, "second thinking" is both practical and economical.

Both the Controllers and the Receivers have been designed to take advantage of the speed, responsiveness and high accuracy of the TRANSAIRE* transmitters—for temperature, pressure or differential pressure. Ask your Taylor Field Engineer how you can profitably use the Taylor Transet System; or write Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada.

Instruments for indicating, recording and controlling temperature, pressure, flow, liquid level, speed, density, load and humidity.

*Trade-Mark



the panel. Checking can be done in the shop where full facilities are available.

6. One standard panel cut-out (5 1/32" x 4 5/32") accommodates 12 different forms of recording and 11 different forms of indicating receivers.

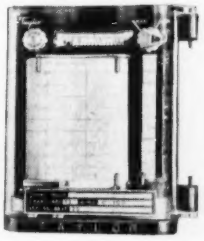
7. You conserve panel space without impairing maintenance facilities.

8. Self-purging case for all receivers is especially appreciated in corrosive or dusty atmospheres.

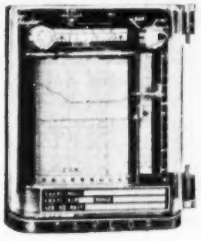
9. Your plant can be kept running smoothly, without expensive shutdowns.

PLUG-IN RECEIVERS

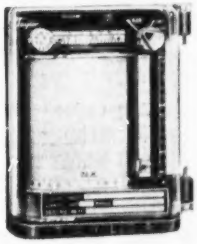
The TRANSET Indicator has all the features of the TRANSET Recorder, but gives no chart record. Gives direct indication of both set point and process variable on single, easy reading 3½" dial. *Mounts in same size panel opening as TRANSET Recorder.*



The TRANSET Recorder has automatic-manual unit, remote set-point indicator. 30 day linear chart, 3 hours visible. Chart reads from left to right on rectilinear coordinates, as an engineer would normally plot variables for study.



The Single Duty Bi-Record Receiver can record a related variable in addition to that under control. For example, in flow measurement it records static pressure as well as differential pressure.

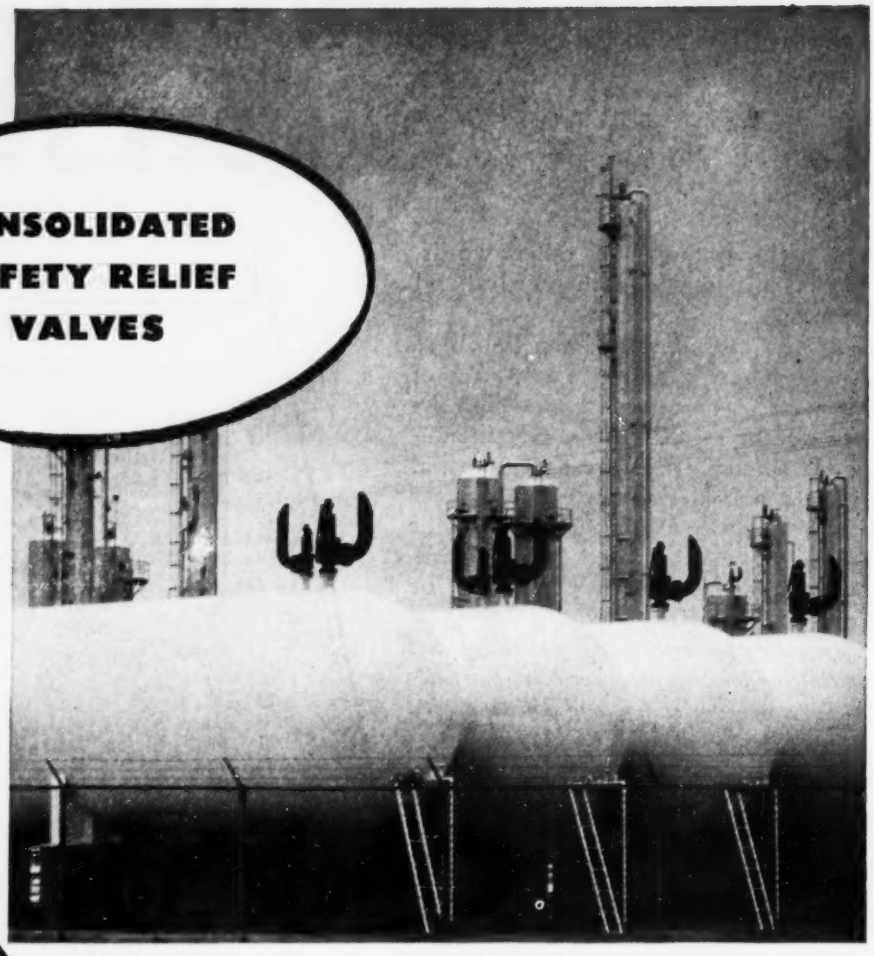


The Pneumatic Set Receiver (Cascade) combines in *one* case without additional panel space the facilities for pneumatic set, automatic control and automatic to manual feature.

MEAN ACCURACY FIRST

For more information circle 18 on inquiry card.

CONSOLIDATED SAFETY RELIEF VALVES



OUTSTANDING FOR SAFE SERVICE

ABSOLUTE PROTECTION against overpressures is the one and only function of Consolidated Safety Relief Valves — and they give it. Proof of their unbeatable performance is evident in the many unfired pressure vessels — gas, vapor and liquid storage tanks, pipelines, pumps — safeguarded by these valves throughout the processing industries.

You want complete protection for your personnel, property and equipment. Consolidated Safety Relief Valves provide it. They don't leak under discharge piping stresses — outside bevel seat and floating guide construction permit the disc to seat on a radial seating surface. *Dependable tightness* is assured in all positions within the deflection range. You can be sure of continuously reliable performance at the rated capacity, even in the most severe service.

Invest in Consolidated Safety Relief Valves and you also get the fundamental advantage of *simple design* — high quality valves that serve better and longer because they have 25% fewer parts than ordinary safety valves.

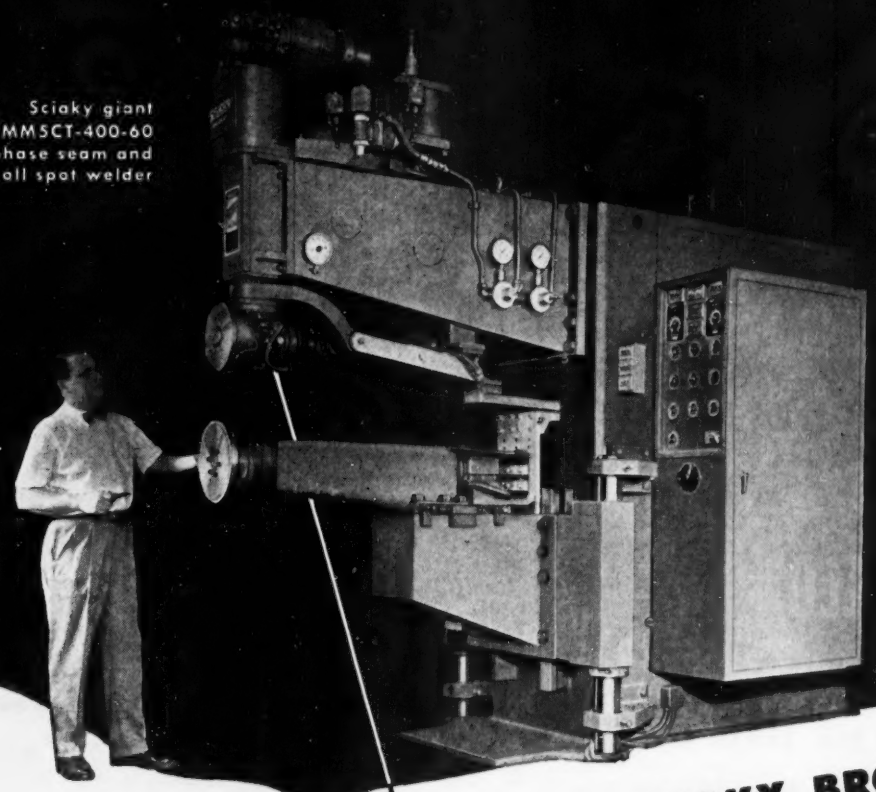
Your local Consolidated Safety Relief Valve Industrial Distributor will explain how much this can mean to you in economical maintenance and simplified standardization. Phone or write him today. He is your best source for quick information and service.

CONSOLIDATED SAFETY RELIEF VALVES

A product of **MANNING, MAXWELL & MOORE, INC.** TULSA, OKLAHOMA

MAKERS OF 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'HANCOCK' VALVES, 'ASHCROFT' GAUGES. BUILDERS OF "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES.

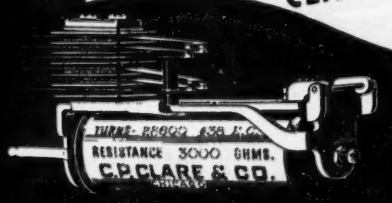
For more information circle 19 on inquiry card. Circle 20 on inquiry card. ⟶



Sciaky giant PMM5CT-400-60 three phase seam and roll spot welder

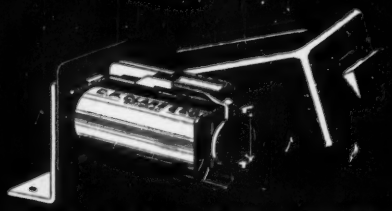
Where ordinary relays won't do... ...that's where you find CLARE RELAYS

IN SCIAKY BROS. GIANT SEAM WELDERS, for instance



CLARE Type C Relay

CLARE Type J Relay



Clare Relays which perform precise functions in control of Sciaky welders are of plug-in type with dust covers

There is nothing small . . . or ordinary . . . about this giant SCIAKY SEAM WELDER. It has a 54" throat depth for longitudinal seam welding . . . a 60" throat depth for circular seam welding . . . and will deliver a maximum of 150,000 amperes of welding current between the electrodes.

Engineers of Sciaky Bros., internationally famous pioneers and inventors of electric resistance welding equipment, found CLARE RELAYS a natural selection for their controls which demand the utmost in precise operation. Among the requirements were:

- ★ **Extremely fast operation . . . Within half a cycle, two relays — one operating another — have to be energized and operate their contacts.**
- ★ **Complete structural uniformity . . . Two relays with coils in series must operate their contacts simultaneously and maintain this performance consistently.**

No, this was no job for ordinary relays. Clare Relays were selected and are used for important precision controls in all Sciaky control panels.

If your product, like the Sciaky welder, is a quality product . . . if you must have only the highest quality components . . . a consultation with the engineers of C. P Clare & Co. can save you time and money. Experienced sales engineers are located in principal cities. Call them direct or write: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable address: CLARELAY.

***FIRST* IN THE INDUSTRIAL FIELD**

CLARE RELAYS

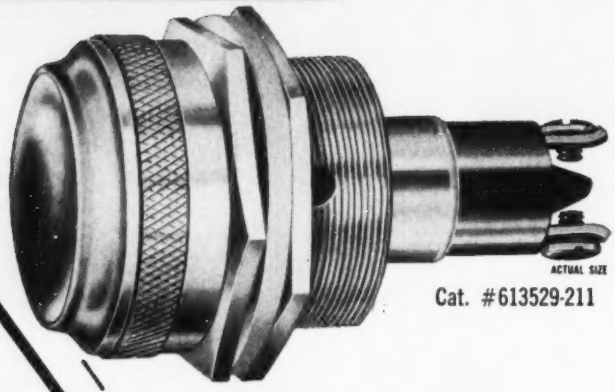
for **YOUR** *product*

WHICH PILOT LIGHT DO YOU NEED?

DIALCO

THE BIG ONE

This Pilot Light Assembly was first made to accommodate the *S-11 lamp* and was intended for use in the cabs of great diesel locomotives.



ACTUAL SIZE

Cat. #613529-211

This BIG one

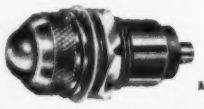
or

this LITTLE one

Dialco HAS THE COMPLETE LINE OF INDICATOR and PANEL LIGHTS

THE LITTLE ONE

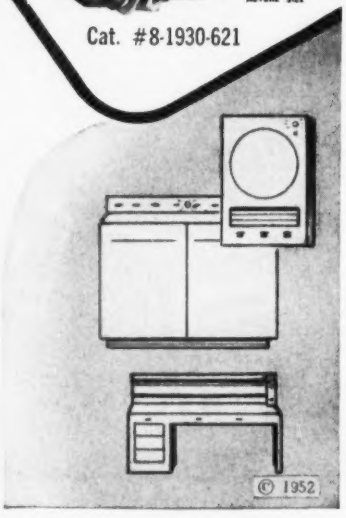
The miniaturization program on defense products required the development of this *sub-miniature* light. It is used on communication equipment and aircraft. Midget flanged base bulbs to fit are rated 1.3, 6, 12, and 28 volts.



ACTUAL SIZE

Cat. #8-1930-621

Samples to suit your own special conditions and requirements will be sent promptly and *without cost*. Just outline your needs. Let our engineering department assist in selecting the *right lamp* and the *best pilot light* for YOU.



© 1952

Write for the Dialco HANDBOOK of PILOT LIGHTS

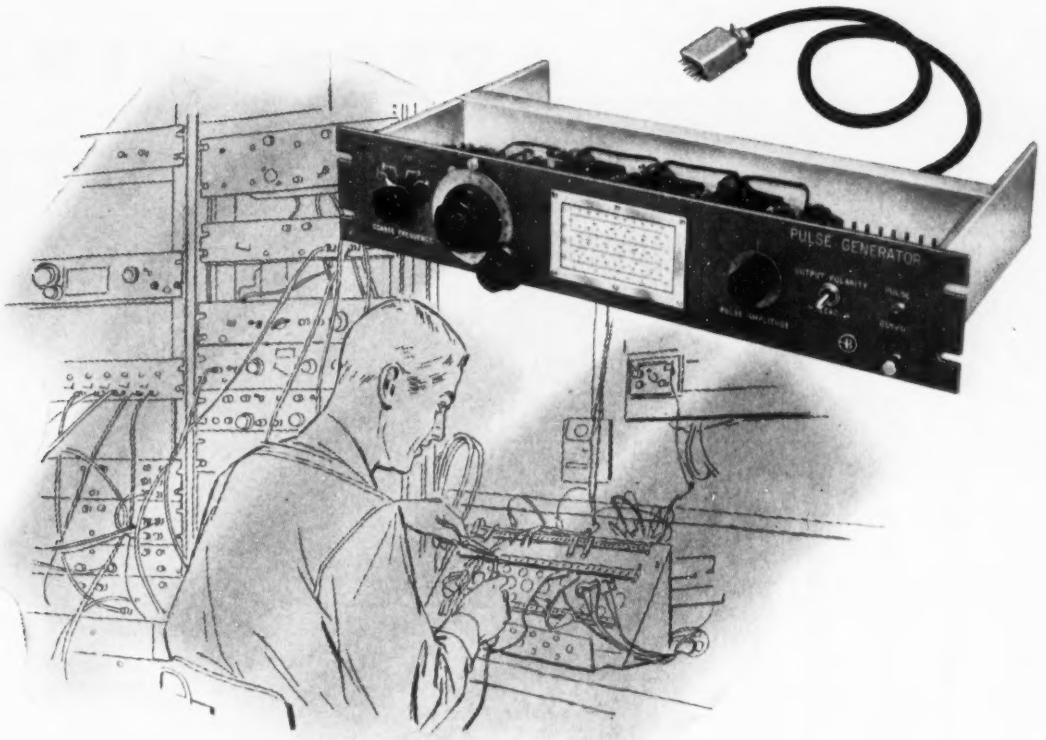
Foremost Manufacturer of Pilot Lights

DIALIGHT CORPORATION

60 STEWART AVE., BROOKLYN 37, N. Y. HYACINTH 7-7600

For more information circle 21 on inquiry card.

FOR APPLICATIONS IN RADAR, TELEMETERING, DIGITAL COMPUTING, TELEVISION, NUCLEAR PHYSICS



"Unitized" Pulse Control Equipment

saves engineering time and money

WHEN you use Burroughs "Unitized" Pulse Control Equipment, you eliminate much of the costly, time-consuming work of developing electronic test circuits. There is a Burroughs pulse control unit for practically every basic function in pulse circuit engineering. You need only plan a block diagram of the pulse circuits you want, assemble the necessary Burroughs units in the plug-in rack and interconnect them with the various standard coaxial cables and accessories. This can be done because each unit performs *one basic operation* such as generating, counting, mixing, gating, or delay.

JUST "PLUG IN" A BURROUGHS PULSE GENERATOR

Any of the three pulse generators offered by Burroughs demonstrates the practical one-basic-function principle behind Burroughs "Unitized" Pulse Control Equipment . . . you simply select the pulse generator for the job and plug in the cables.

Burroughs Pulse Generator, Type 1002B, generates 0.1 microsecond pulses at frequencies continuously variable from 0.2 megacycles to 4.5 megacycles in four overlapping bands. A calibrated, L-C controlled, sine-wave oscillator controls the frequency. Output amplitude, which is only affected by frequency changes in the ranges above 2 megacycles, can be varied from 10 to 32 volts and the polarity of the output pulse is reversible.

Like other Burroughs units, this pulse generator is designed and engineered so that it can be added to equipment now in use, selected as a basic component of new equipment, or used repeatedly for testing or as a component in future pulse control jobs.

For full information on Burroughs "Unitized" Pulse Control Equipment, call or write Department 15, Electronic Instruments Division, Burroughs Research Center, 511 N. Broad St., Philadelphia 23, Pa.

PULSE GENERATORS
COINCIDENCE DETECTORS
PULSE DELAY CIRCUITS
FLIP-FLOP CIRCUITS
PULSE GATERS
CHANNEL SELECTORS
MIXERS

ELECTRONIC INSTRUMENTS DIVISION
Burroughs

For more information circle 22 on inquiry card.

FOR TOP ENGINEERING KNOW-HOW ON PERMANENT MAGNETS CONSULT INDIANA

PERMANENT MAGNETS

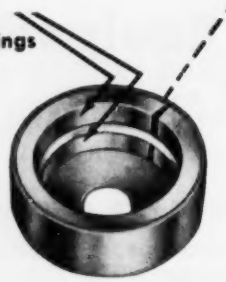
STEWART SW WARNER **STEWART-WARNER**

tailored to meet your specifications

tachometer

- **Top engineering**
- **35,000 Permanent magnet applications**
- **Magnets from all types of material**

cunife rings



permanent magnet assembly

These are the assets at your disposal which permit INDIANA to tailor their permanent magnets to your design specifications.

Just as Stewart-Warner did, so you, too, can place your confidence in INDIANA for quality permanent magnets . . . for skill in manufacture . . . for cost-cutting engineering aid. Rigorous quality control in every step of production is your assurance of exact magnetic and physical characteristics. For help with your problem, write INDIANA, today.

PERMANENT MAGNETS MAY DO IT BETTER

DESIGN SUMMARY

Equipment—Electric Tachometer, manufactured by Stewart-Warner Corp., Chicago.

Application—Permanent magnet assembly.

Problem—To design a permanent magnet which would produce sufficient torque and give added stability to this instrument.

Solution—By varying the analysis and heat treatment, INDIANA engineers developed a special Cunife permanent magnet which provided the necessary torque and improved stability. Furthermore, this special Cunife magnet lent itself better to the limited space resulting from the new design.

WRITE FOR DESIGN MANUAL NO. 4-D7

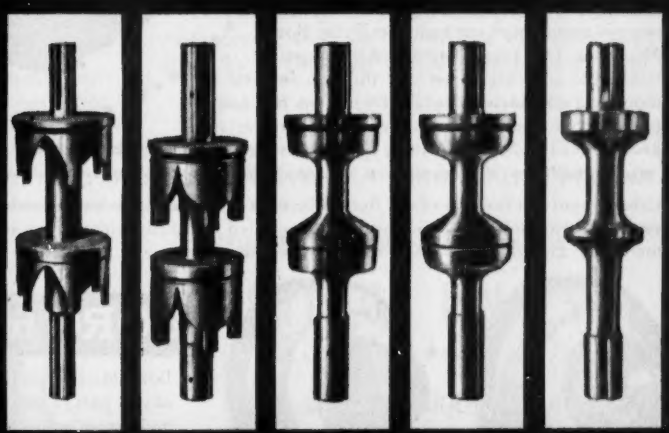
INDIANA PERMANENT MAGNETS

THE INDIANA STEEL PRODUCTS COMPANY • VALPARAISO, INDIANA

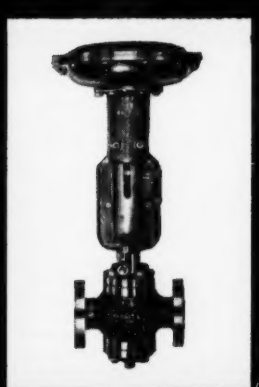
WORLD'S LARGEST MANUFACTURER OF PERMANENT MAGNETS

For more information circle **23** on inquiry card. Circle **24** on inquiry card →

WIDE SELECTION . . .



for any valve application



Discs for the Honeywell Series 700 Valve include single and double-seated V-ported and contoured types, each with either linear or equal-percentage characteristics, plus a flat disc for on-off control . . . all ground and polished . . . all designed to retain characteristics under severe service. The Honeywell Series 700 Valve comes in a full range of styles and sizes . . . has *all* the features you look for in a fine valve. Write today for your copy of Bulletin 700-2. MINNEAPOLIS HONEYWELL REGULATOR CO., *Industrial Division,* 1908 Windrim Avenue, Philadelphia 44, Pa.

MINNEAPOLIS

Honeywell

VALVE PRODUCTS

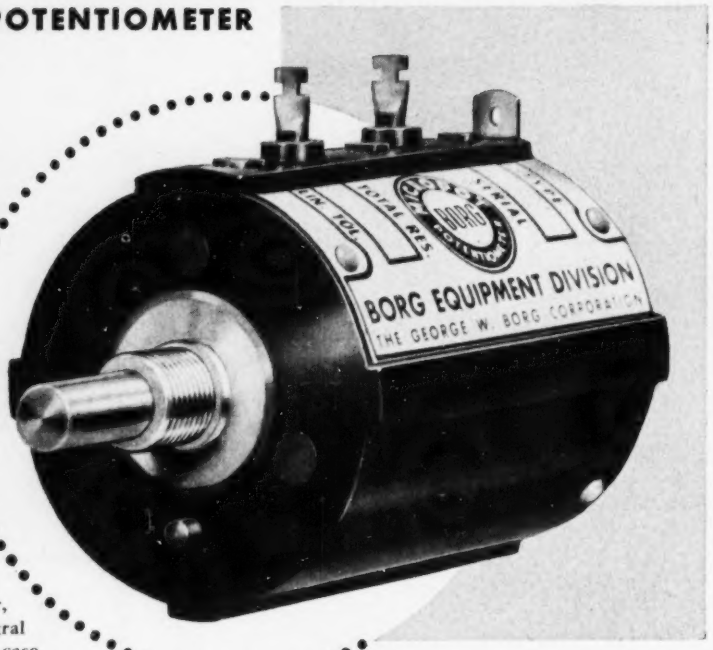
H HONEYWELL

First in Controls

PRECISION TEN-TURN POTENTIOMETER

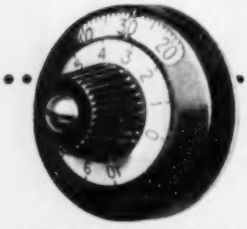
BORG MICROPOT

- PERMANENT "MICRO" ACCURACY
- ZERO-BASED LINEARITY OF ±.25%, ±0.1% AND ±0.05%

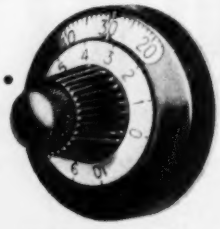


For applications requiring maximum, permanent accuracy of settings, specify the Borg Micropot Ten-Turn Potentiometer. Superior, consistent accuracy is assured through integral moulding of the resistance wire within the case, plus operation of the moving contact by a precision ground lead screw. All Borg Micropots are automatically machine-tested for a *zero-based* linearity of ±.25% or ±0.1%, with overall resistance ±5%. Available on special request with ±0.05% linearity.

Other important features of the Borg Micropot are accuracy in setting and resetting (due to Borg anti-backlash device) . . . very fine resolution . . . rigid terminals, moulded integrally with the housing. Micropots are available for immediate shipment in 1.15 to 3 ohm and 30 to 250,000 ohm ranges.



BORG MICRODIAL 746-A
Friction Screw



BORG MICRODIAL 746-B
Friction Knob

BORG ten-turn MICRODIAL

Borg Microdials indicate contact position to an indexed accuracy of one part in one thousand. For use on Borg Micropots or similar multi-turn applications. It is composed of two concentric dials . . . one for counting increments of each turn in 1/100ths, the other for counting turns. Borg Microdials can be friction-held in any position against accidental turning.

FOR IMMEDIATE SERVICE CALL YOUR NEAREST BORG REPRESENTATIVE

ARIZONA AND CALIFORNIA
W. S. Harmon Company
1638 South LaCienga Blvd.
Los Angeles 35
Phones: Bradshaw 2-3321
Crestview 6-3027

NEW ENGLAND STATES
Gerber Sales Company
42 Church St., New Haven
Phone: University 5-2147
739 Boylston St., Boston 16
Phone: COpley 7-0061-0062

DEL., EASTERN PA., SOUTHERN N.J.
L. Parker Naudain
Broad St. Station Bldg.
Philadelphia 3
Phone: Rittenhouse 6-3185

ILLINOIS
Jerome Kleker Company
177 Sunset Ave., Glen Ellyn
Phone: 2297

INDIANA
Hoemig Sales Company
1730 Clover Lane, Fort Wayne
Phone: Anthony 2083

KAN., MO., NEB., OKLA., TEXAS
The George E. Harris Co.
1734 N. Hillside, Wichita
Phones: 62-2731 and 63-9226

John Pilkington
6315 Brookside, Kansas City
Phone: Delmar 9600

Lee Thayer
6635 Delmar St., St. Louis
Phone: Volunteer 3-6550

Richard O'Barr
304 Sinclair Bldg., Fort Worth
Phone: Edison 7148

MD., VA., DISTRICT OF COLUMBIA
J. J. Maguire
742 Investment Bldg., Washington
Phone: National 4247

UPPER NEW YORK
Martin P. Andrews
Fayetteville
Phone: 65-8405

GREATER NEW YORK
David Sonkin
Lucas Building
10 Fiske Place, Mt. Vernon
Phone: 8-9809-10-11

OHIO, KY., WESTERN PA.
John O. Olsen Co.
16201 Shaker Blvd., Cleveland
Phone: WYoming 1-2624

William F. Needles
4016 Diehl Ave., Cincinnati
Phone: SYcamore 1297

Paul M. Lawman
1262 Shadycrest, Pittsburgh
Phone: LOcust 1-3273

Micropots with Standard resistance values may be obtained from:

Allied Radio Corp., Chicago, Ill. · Radio Shack Corp., Boston, Mass. · Herbach and Rademan, Philadelphia, Pa.

BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
Janesville, Wisconsin

For more information circle 25 on inquiry card. Circle 26 on inquiry card. →

Faster... For testing...

COMPACT, PORTABLE
BENCH-TYPE TESTING UNIT FOR RAPID HIGH and LOW TEMPERATURES

Primarily developed for a branch of the armed forces, this high and low temperature testing unit has a temperature range from -80° F. to +185° F. Rapid temperature pull-down to -80° F. requires 30 minutes or less. Heat application is accomplished through reverse cycle refrigeration. Hazards of open heating elements are eliminated. Test chamber dimensions are 12"x12"x12" and the overall dimensions are 50" long, 26" high and 20" deep. Approximate weight is 450 pounds. The unit is compact and is entirely self contained. Controls are simplified and easy to operate. Equipped with air-cooled compressors, the unit is quiet in operation. Cabinet is of stainless steel with all controls visible. A blower is provided for even distribution of temperatures and greater testing accuracy. The door illustrated is a latch type door providing for complete removal from the cabinet. Holes may be drilled for electrical contacts.

This is one of the many examples of WEBBER engineering skill and another of the many firsts built by WEBBER in the low temperature field.

Write for more complete information:

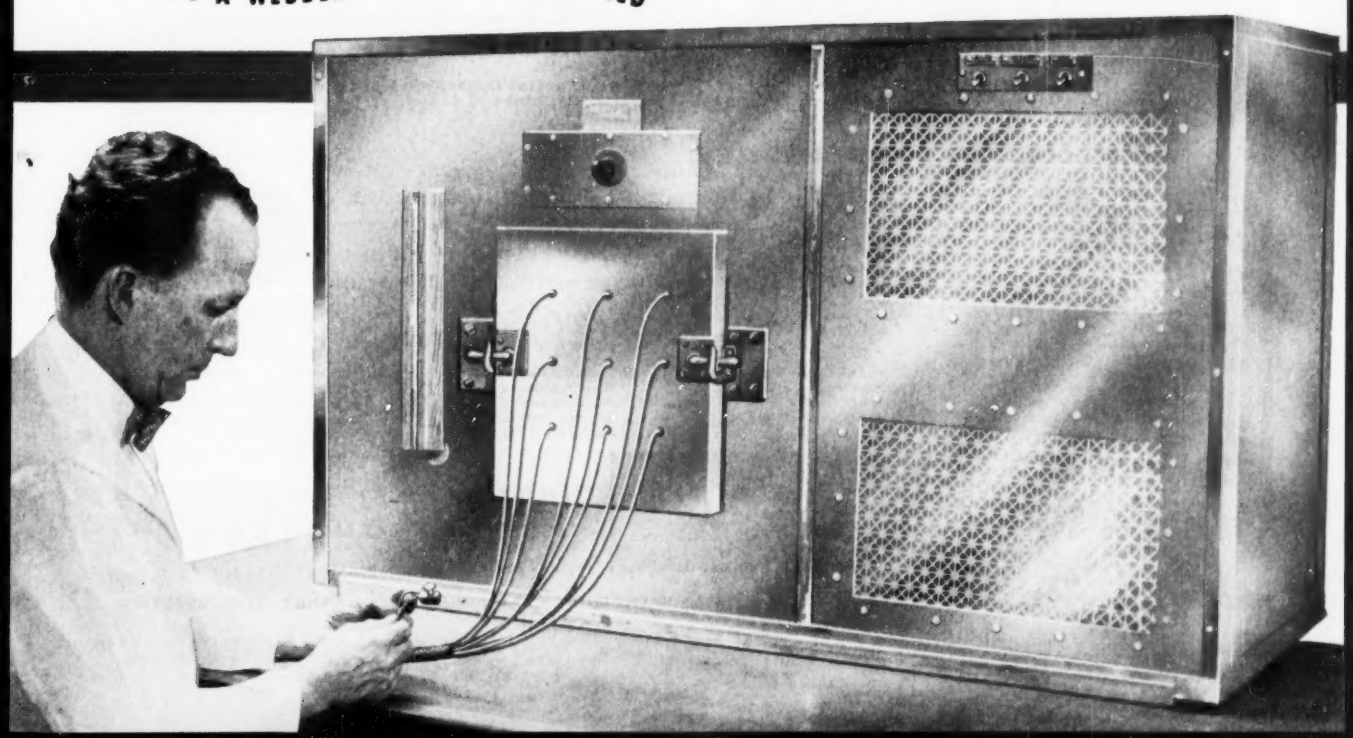
INDUSTRIAL FREEZER DIVISION
WEBBER MANUFACTURING COMPANY, INC., 2748 MADISON AVENUE, INDIANAPOLIS 3, INDIANA
(Formerly Webber Appliance Co., Inc.)

WEBBER
TRADE MARK

COMPLETE TEMPERATURE RANGE
TESTING UNITS

LOW-TEMPERATURE
INDUSTRIAL FREEZERS

THERE'S A WEBBER UNIT FOR EVERY NEED



New!

±.01% Linearity

Infinite Resolution

REVOLUTIONARY, UNIQUE

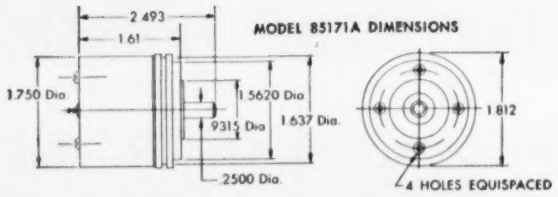
spiralpot

MULTI-TURN SLIDE WIRE POTENTIOMETER

Long Life

Low Noise

MODEL 85171A DIMENSIONS



Two New Models Added to Spiralpot Line

New precision grades of Spiralpot potentiometers meet exacting requirements of Servo and Computer design.

Model 85171A—one to 20 turns; 2 to 5,000 ohms; 1.750" Diameter. Now available with linearities to ±0.01%!

Model 85172—25 to 40 turns; 50 to 10,000 ohms; 1.750" Diameter

Model 85173—1 to 40 turns; 6 to 25,000 ohms; 3.320" Diameter

DESIGN FEATURES

POSITIVE 500 OZ. IN. END STOPS
NORMAL OR ZERO BASE LINEARITIES
RESISTANCES FROM 2 TO 25,000 OHMS
NO BACKLASH
LOW INDUCTANCE AND CAPACITIVE EFFECTS
LOW TORQUE: BALL BEARINGS
SYNCHRO-MOUNTING
PRECISION GROUND SHAFT

SPECIFICATIONS

RESISTANCE: Model 85171A— 2 to 5,000 ohms
Model 85172 —40 to 10,000 ohms
Model 85173 — 5 to 25,000 ohms

POWER RATING: 5.0 watts at ambient = +25°C (85171A)
10.0 watts at ambient = +25°C (85173)

LINEARITIES AVAILABLE: (Based on percent of terminal voltage)

- ±0.1% Normal (Independent)
- ±0.1% Zero Base
- ±0.05% Normal (Independent)
- ±0.05% Zero Base
- ±0.025% Normal (Independent)
- ±0.025% Zero Base
- ±0.01% Normal (Independent) (85171A only)

RESOLUTION: Infinite. (True Slide Wire)

MECHANICAL SHAFT ROTATION: One to 40 turns Tolerances +3°, −0° on standard units. +1°, −0° on precision grade units.

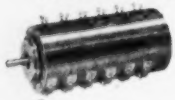
TORQUE: Starting: Less than 0.6 oz.-in. Running: less than 0.3 oz.-in.

LIFE: Will operate within specifications after one million cycles (20 million revolutions for a 10-turn unit).

TEMPERATURE RATING: Operating range from −55°C. to +71°C.

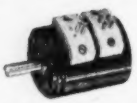
VOLTAGE BREAKDOWN: Will withstand 1,000v 60-cycle (rms) for 5 minutes. (At sea level).

OTHER GIANNINI POTENTIOMETERS



Gangpot

2½" dia; ¼" shaft; 1 to 6 sections, Aluminum Case; 360° rotation; ±0.3% lin. 4 watts/sec; 2K to 300K ohms; Vernier Screwdriver Phasing. Ball bearings.



Minigang

1⅛" dia; ¼" shaft; 1 to 6 sections, Aluminum Case; 360° rotation; ±0.5% lin. 2 watts/sec; 500 to 70,000 ohms, Ball bearings.

Rectipot

Straight-line motion along axis. Linear or functional output. 200 to 60,000 ohms. 5 sizes, 1" dia. from 2.33" to 6.54" long. Stroke ½" to 5".

Universal

1.74" dia; ¼" shaft; 360° rotation; ±0.3% lin; 4 watts; 2K to 200K ohms, Aluminum Case. Ball Bearings. 40 and 50 db log functions 20K ohms.

Giannini INSTRUMENT QUALITY POTENTIOMETERS

G. M. GIANNINI & CO. INC., PASADENA 1, CALIFORNIA—EAST ORANGE, NEW JERSEY

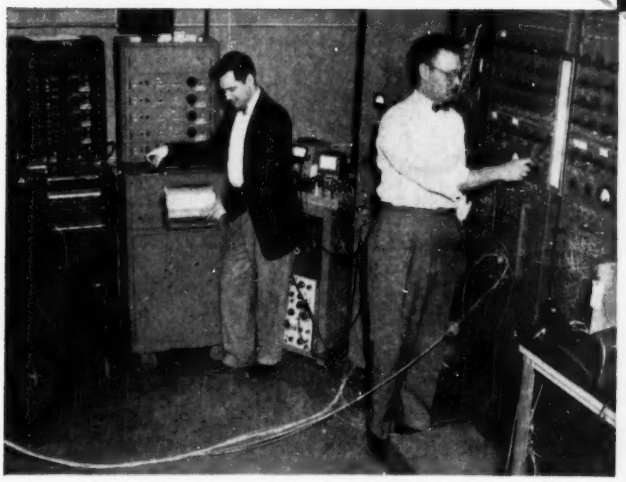
For more information circle 27 on inquiry card.

SANBORN OSCILLOGRAPH RECORDING SYSTEMS HAVE MANY APPLICATIONS

Sanborn Recorders Help Speed Flight Design

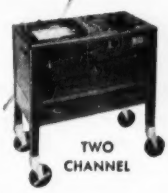
SPERRY GYROSCOPE COMPANY uses a two-channel Sanborn Recording System for basic research on their Zero Reader* Flight Director, a device which simplifies the manual control of aircraft. The Sanborn System shown above is recording the output of a flight simulator that solves Zero Reader equations.

*T. M. REG. U. S. PAT. OFF.



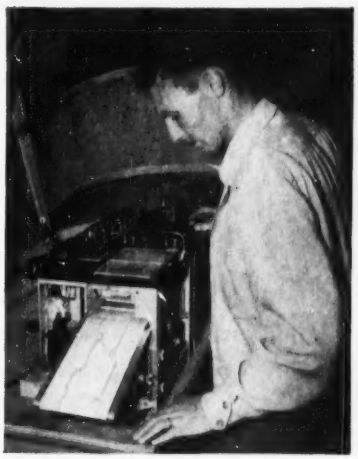
At McDONNELL AIRCRAFT CORPORATION the movements of a guided missile are simulated by high-precision analog computers which in turn send *eight* different resultant electric signals into two Sanborn four-channel Recording Systems (left) for the graphic recording of the hypothetical results of the guided missile problem.

FOUR CHANNEL



TWO CHANNEL

ONE CHANNEL



At DOUGLAS AIRCRAFT COMPANY'S Flight Test Section, a Sanborn two-channel Recording System (shown removed from case for field operation) is used in conjunction with a telemeter radio link to record surface motion vibration in a flying aircraft while it is performing tests requiring continual monitoring. Recorded tracings provide the necessary permanent visual time history for comparison of the two events recorded and a study of their individual characteristics.

How can Sanborn help you?

Sanborn one-, two-, and four-channel Recording Systems can provide an accurate and permanent graphic registration of almost any electrical phenomena whose frequency spectrum falls within the range of zero to 100 cycles per second. The availability and ready *interchangeability* of amplifiers and preamplifiers offer a wide range of use.

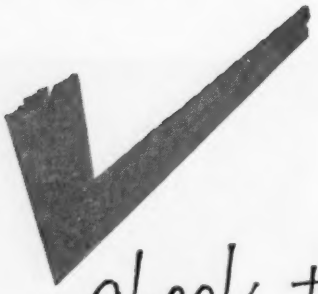
Records are traced by heated stylus on plastic coated strip-chart paper, and are in true rectangular coordinates. Other Sanborn advantages include: a high torque movement (200,000 dyne cms per cm deflection); built-in code and time markers; and a wide choice of paper speeds and channels.

Sanborn engineers will be pleased to make recommendations as to what type of equipment will best solve your recording problem. When writing, include the lower and upper limits and the frequency range of the phenomena to be recorded, and the type of transducer.

Ask for a copy of our "Applicability Folder" which presents a table of uses, complete performance data and specifications, brief descriptions of Sanborn Recording Systems and explanations of how their amplifiers may be readily interchanged.

SANBORN CO. INDUSTRIAL DIVISION
CAMBRIDGE 39, MASSACHUSETTS

For more information circle 28 on inquiry card.

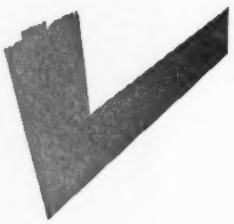


check the

dollars and sense reasons

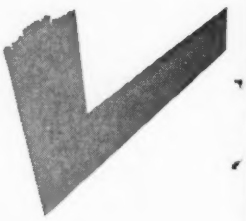
for using HAGAN

automatic combustion controls



and HAGAN

ring balance flow meters



HAGAN
HALL
BUROMIN
CALGON

For more information circle **29** on inquiry card.

It makes good sense to invest your dollars in Hagan Combustion Controls and Hagan Meters. The investment pays real dividends in the following ways:

accuracy

Hagan Automatic Controls and Ring Balance Meters are accurate, whether the system is simple or complex. This accuracy is reflected in savings which, during the life of the boiler, usually amount to many times the cost of the equipment.

dependability

Hagan Controls and Ring Balance Meters are dependable in their performance, year after year. Long life and low maintenance costs are inherent in all designs.

versatility

One boiler or many, one or more fuels, Hagan Controls handle the job easily. Hagan Ring Balance Flow Meters are the most versatile meters available for measuring and recording flow of liquids and gases.

Whatever your metering or combustion control problems, let Hagan Engineers help you solve them. Our experience is at your service. Write, or call us, at

HAGAN CORPORATION

HAGAN BUILDING, PITTSBURGH 30, PA.

BOILER COMBUSTION CONTROL SYSTEMS
RING BALANCE FLOW AND PRESSURE INSTRUMENTS
METALLURGICAL FURNACE CONTROL SYSTEMS
CONTROL SYSTEMS FOR AUTOMOTIVE AND
AERONAUTICAL TESTING FACILITIES

For more information circle **29** on inquiry card.

Here is Why!

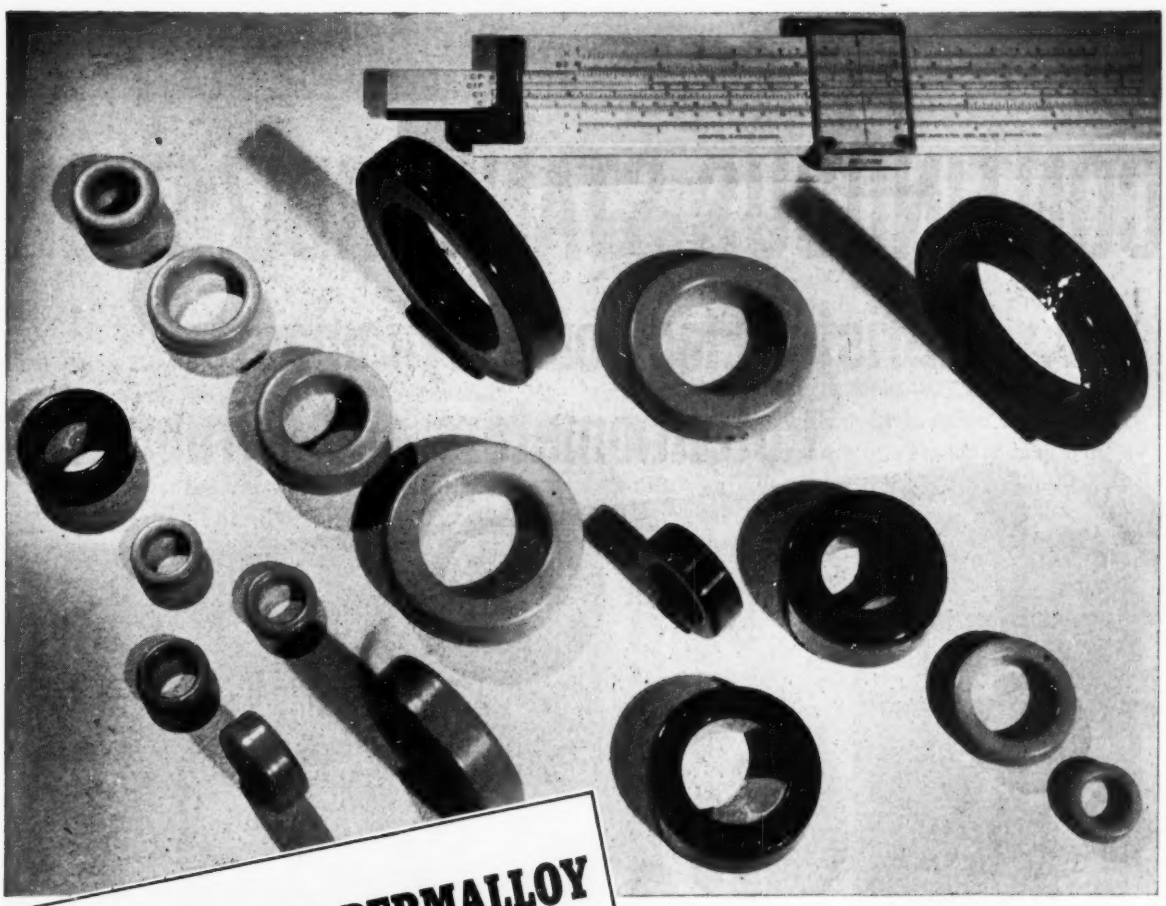
You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

For more information circle 30 on inquiry card.



MOLYBDENUM PERMALLOY POWDER CORES*

(New technical data now available)

HIGH Q TOROIDS for use in Loading Coils, Filters, Broadband Carrier Systems and Networks—for frequencies up to 200 K C

COMPLETE LINE OF CORES TO MEET YOUR NEEDS

- ★ **Furnished in four standard permeabilities—125, 60, 26 and 14.**
- ★ **Available in a wide range of sizes to obtain nominal inductances as high as 281 mh/1000 turns.**
- ★ **These toroidal cores are given various types of enamel and varnish finishes, some of which permit winding with heavy Formex insulated wire without supplementary insulation over the core.**

For high Q in a small volume, characterized by low eddy current and hysteresis losses, ARNOLD Moly Permalloy Powder Toroidal Cores are commercially available to meet high standards of physical and electrical requirements. They provide constant permeability over a wide range of flux density. The 125 Mu cores are recommended for use up to 15 kc, 60 Mu at 10 to 50 kc, 26 Mu at 30 to 75 kc, and 14 Mu at 50 to 200 kc. Many of these cores may be furnished stabilized to provide constant permeability ($\pm 0.1\%$) over a specific temperature range.

*Manufactured under license arrangements with Western Electric Company

W&D 4744

THE ARNOLD ENGINEERING COMPANY

SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION

General Office & Plant: Marengo, Illinois

DISTRICT SALES OFFICES . . . Boston: 200 Berkeley St.

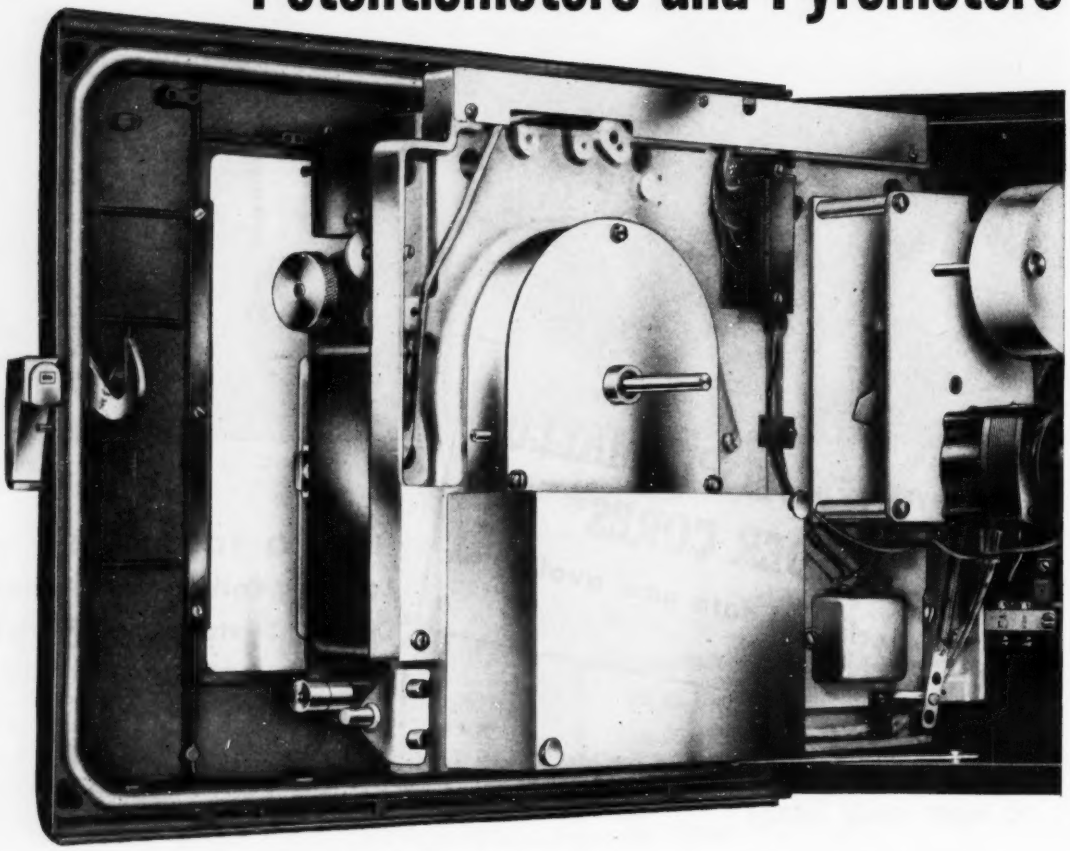
New York: 350 Fifth Ave. Los Angeles: 3450 Wilshire Blvd.

For more information circle 31 on inquiry card.

WHAT'S NEW AT BRISTOL . . . . WHAT'S NEW AT BRISTOL . . . .

CONTINUOUS STANDARDIZATION

...in Bristol Electronic Dynamaster Potentiometers and Pyrometers



LOOK FOR OUTSTANDING NEW DEVELOPMENTS FROM BRISTOL

BRISTOL

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle 32 on inquiry card.

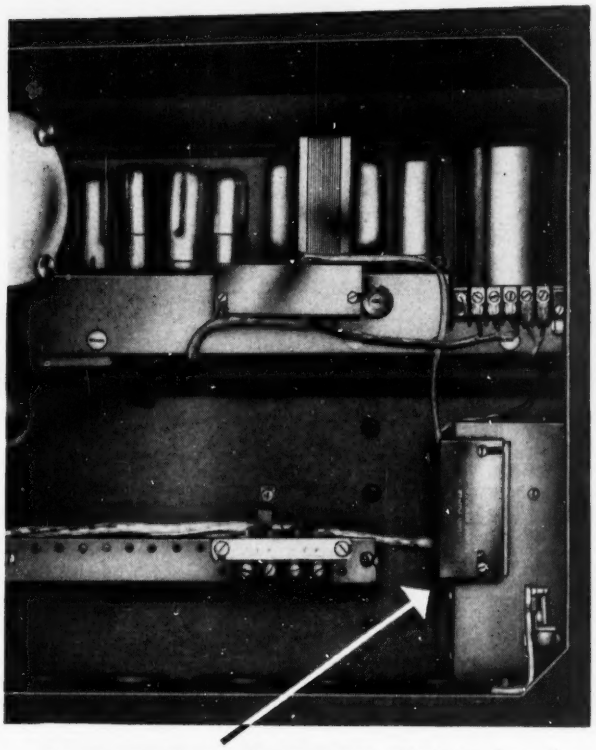
WHAT'S NEW AT BRISTOL . . . . WHAT'S NEW AT BRISTOL

with no dry cells

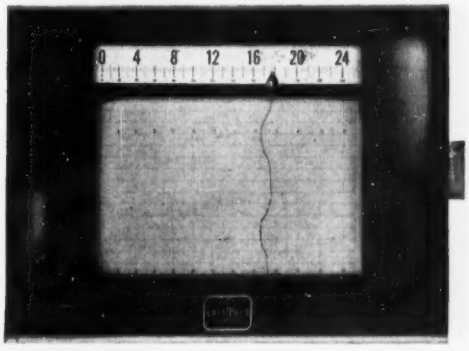
• **CONTINUOUS STANDARDIZATION** eliminates need for dry cells—supplies voltage that is continuously compared with standard cell.

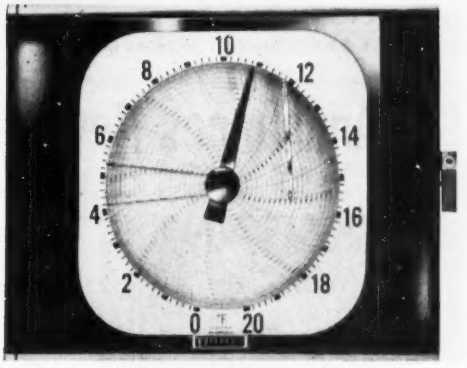
• **CONTINUOUS OPERATION—NO TIME OUT.** With continuous standardization, the potentiometer is free to continuously measure, record, and control. No time out or interruption is required for periodic standardization.

• **NO STANDARDIZING MECHANISM:** Continuous standardization is taken care of electrically. The absence of a standardizing mechanism simplifies the instrument considerably.



Continuous Standardization Unit: Eliminates dry cell—no interruptions in the operation of the potentiometer for standardization—no standardizing mechanism.





Bristol Electronic Dynamasters are made in round- and strip-chart, single- and multiple-record recorders, air-operated and electric controllers (all types of control actions). Two-pen and Program Control.

For the complete story on the modern Bristol Dynamaster, write for free 35-page booklet P1245. The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.

THE DEPENDABLE GUIDEPOST OF INDUSTRY

3.17

For more information circle 32 on inquiry card.

LABORATORY INSTRUMENTS

NEW LINE OF G-E INSTRUMENTS INCLUDES BOTH ¼% (SHOWN ABOVE) AND ½% ACCURACY CLASS. BOTH FEATURE IMPROVED READABILITY.

G-E Announces New High-accuracy Portable Instruments

ACCURATE READINGS are now assured with long, highly-legible, 5½-inch mirror scale.

Designed for precision work, General Electric's new line of DP-12 portable instruments features accuracy of ¼ of 1% of full scale. Also available for less critical applications is the new line of DP-11 instruments having an accuracy of ½ of 1% of full scale. Both ammeters and voltmeters are available in a wide range of ratings, in both lines.

NEW MOLDED WINDOW

The instrument's new molded window permits illumination of the large open scale from the front and from three sides, and assures maximum scale lighting. The case of these new G-E instruments is made of break-resistant "Textolite."*

SPRING-MOUNTED BEARINGS

The new G-E instruments are equipped with spring-mounted jewel bearings for maximum protection against shock damage.

CONCENTRIC MAGNETIC MECHANISM

The mechanism is of the permanent-magnet, moving-coil type known as "concentric magnet" construction. It assures the utmost in magnetic efficiency.

Priced from $116.00**. Check coupon for free copy of bulletin: GEC-979.

You can put your confidence in—

GENERAL ELECTRIC

For more information circle **33** on inquiry card.

FOR PRECISION MEASUREMENT

New G-E Galvanometer Features Easy-to-read, Tilted Scale

With its scale surface tilted 15 degrees from the vertical, the new General Electric galvanometer is now easier to read from any position. Retaining such features as high sensitivity, flexibility, and easily interchangeable elements for different sensitivities, the new galvanometer now provides for a rough zero adjustment without opening the cover.

EASY TO REPLACE LIGHT SOURCE

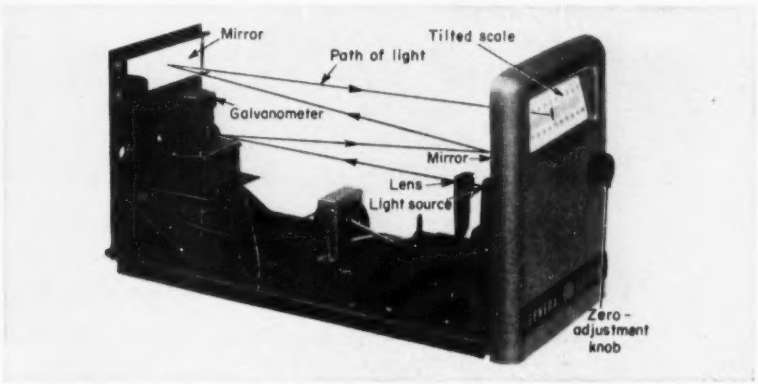
The light source of the new G-E galvanometer can be replaced simply, without danger of injury to the hairline or other internal parts.

NEW METAL CASE

Replacing the wooden case of previous models, an attractive, light metal case with gray hammer-tone finish now is used to enclose the instrument.

Price is $152.00**. Check coupon for bulletin.

ATTRACTIVE NEW CASE conforms to latest trends in laboratory instrument design.



SELF-CONTAINED UNIT, the new G-E galvanometer is a compact and sturdy instrument. No separate lamp stand or scale is required. New tilted scale is easier to read.

General Electric Oscillograph Aids Relay Manufacturer in Developmental Testing

Oscillograms in one minute was the answer recently when a large electrical manufacturer found it necessary to make some rapid development tests on a new type relay. The General Electric PM-18 oscillograph, equipped with a Polaroid-Land film holder enabled the manufacturer to obtain permanent records of each test one minute after test, and to complete an entire series of eight tests in one hour.

ONE-MINUTE OSCILLOGRAMS helped manufacturer make rapid development tests.

HIGH SENSITIVITY

The General Electric PM-18 oscillograph features a variety of highly-sensitive galvanometers and adjustable time sweep of 0.1 to 0.5 seconds.

4 SIMULTANEOUS RECORDS

Designed to record two, three, or four currents or voltages simultaneously, the PM-18 can be used for sine-wave frequencies up to 500 cycles per second with its Polaroid-Land film holder, and up to 2000 cycles per second with the continuous-drive film-holder attachment.

For more information circle **33** on inquiry card.

EASILY PORTABLE

Weighing only 30 pounds, the PM-18 can be readily carried to where it is needed. It is not necessary to bring the job to the oscillograph.

LOW COST

The General Electric PM-18 oscillograph, complete with Polaroid-Land film holder and two galvanometers costs only $850.59**. Check coupon for free bulletin.

* Registered trademark, General Electric Co.
** Manufacturer's suggested retail price.

SECTION B 605-36, GENERAL ELECTRIC, SCHENECTADY 5, N. Y.

Please send me the following bulletins.

- ☐ Portable Indicators (GEC-979)
- ☐ Portable Galvanometer (GEC-694B)
- ☐ Type PM-18 Oscillograph (GEC-580)

NAME .....

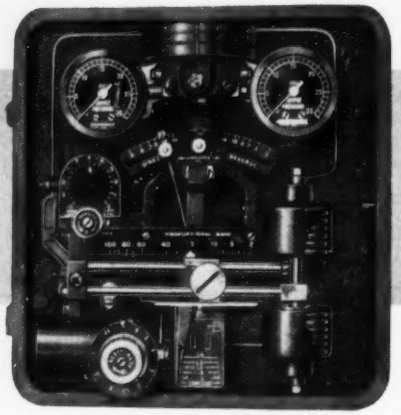
COMPANY .....

STREET .....

CITY ..... ZONE ... STATE ....

NEW MASONEILAN 12000 SERIES
Offer Accurate, Sensitive,
New Ease of Selection;

Proportional Controller



Proportional-Reset Controller

These new controllers reflect a realistic blending of past experience and current design trends, combining advanced features which reduce weight, improve adjustability and increase ease of selection, installation and servicing.

Consider what these design improvements can mean to you . . .

UNIT CONSTRUCTION

Unit subassemblies of the control mechanisms (proportional, or proportional-reset, unit and level setting mechanism) are mounted on the mechanism bracket which is in turn rigidly attached, piloted and doweled to the torque tube housing. Thus, individual units are fixed in position, unaffected by possible distortion of the case, yet are readiiy removable for servicing or interchange. Other sub-assemblies (pilot and manifold) are mounted in the rugged aluminum case which is finished and gasketed for outdoor service. Cover is closed by a positive cam-type latch.

SIMPLE AIR CIRCUITS

The high-capacity, balanced, amplifying, pilot with frictionless floating-action valve and cleanable sapphire orifice, is connected to the forged brass manifold which contains most air passages. Tubing in the proportional controller is limited to two short lines. The nozzle is easily removable for cleaning, and after replacement requires no aligning. Special ring type adapters facilitate connections.

EASE OF ADJUSTMENT

Proportional band setting . . . is made on a rod-type cantilever spring by a self-aligning clamp tightened by a large knurled knob located in front of the mechanism. A four-inch direct reading scale indicates the setting.

Control action and specific gravity setting . . . are selected by attaching the control link to desired side of reversing arc along the specific gravity scale, graduated from 0.5 to 1.4. The arc is easily reversible when instrument mounting is changed to opposite side of displacer.

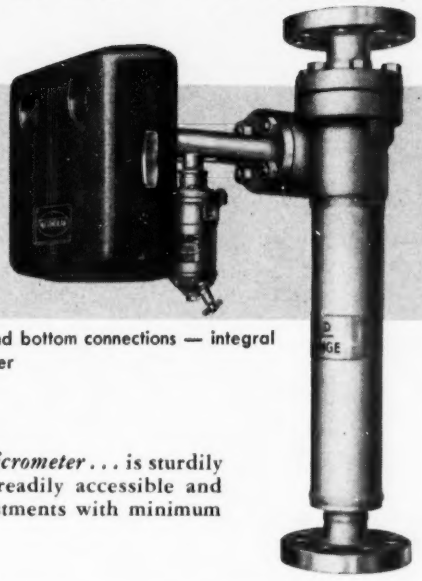
Set point . . . is precisely adjustable throughout entire range by turning setting knob over 270° arc scale, 2″ long. Scale is reversible when control action is changed.

Direct level indication . . . is provided by a sturdy pointer fastened directly to the torque tube rod. The scale is graduated for both left and right hand instrument mounting and for several specific gravities.

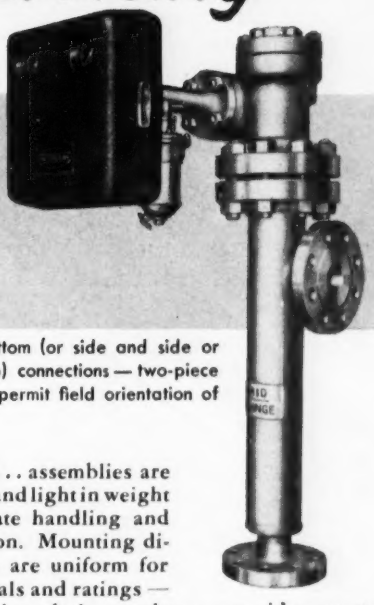
FOR A WIDE VARIETY OF APPLICATIONS

For more information circle 34 on inquiry card.

LIQUID LEVEL CONTROLLERS . . .
Dependable Control – plus
Adjustment and Servicing



Top and bottom connections — integral chamber



Side and bottom (or side and side or side and top) connections — two-piece chamber (to permit field orientation of instrument)

Alignment micrometer . . . is sturdily mounted, is readily accessible and permits adjustments with minimum disturbance.

VERSATILITY

The proportional controller . . . may be used as a *Transmitter* and can be converted in the field to a

Differential gap controller . . . by simply reversing position of the coil spring and bellows in the proportional unit; or

Proportional-reset controller . . . by interchanging the proportional unit and the proportional-reset unit.

STURDY, COMPACT, ACCURATE MEASURING UNIT

All parts of the *Torque Tube Assembly* are made of a single alloy, individual parts being welded to form an integral unit. Knife-edge bearings support both ends of torque tube. Torque tube housing is removable from mechanism chamber.

Stainless . . . steel tubing *Displacers* designed so that standard control mechanism can be used for all ranges, are attached to the torque arm by hangers with modified-knife-edge hooks. Hanger extensions may be integral or detachable.

Chamber . . . assemblies are compact and light in weight to facilitate handling and installation. Mounting dimensions are uniform for all materials and ratings — and are in whole numbers; on side-mounted types mounting dimensions equal level range.

VARIETY OF TYPES, MOUNTINGS, MATERIALS

Instrument Types include *Proportional, Proportional-reset, Differential Gap Controllers* and *Transmitters;* or any combination of two of these in larger case. *Mounting Types* include top and bottom, side and side or side and either top or bottom, with screwed or flanged connections; also top or side of vessel with flanged connections. Instrument mounting left or right of displacer.

Ratings up to 2500 lbs. ASA.

Materials include iron (14″ & 32″ only), steel or alloy chambers; stainless steel displacers; inconel (or wide selection of other materials) torque tube assemblies.

Ranges — 14″, 32″, 48″, 60″, 72″, 84″, 96″, 120″

Complete details sent on request. Address

ALL HIGH Quality Coefficient PRODUCTS

MASON-NEILAN REGULATOR CO.

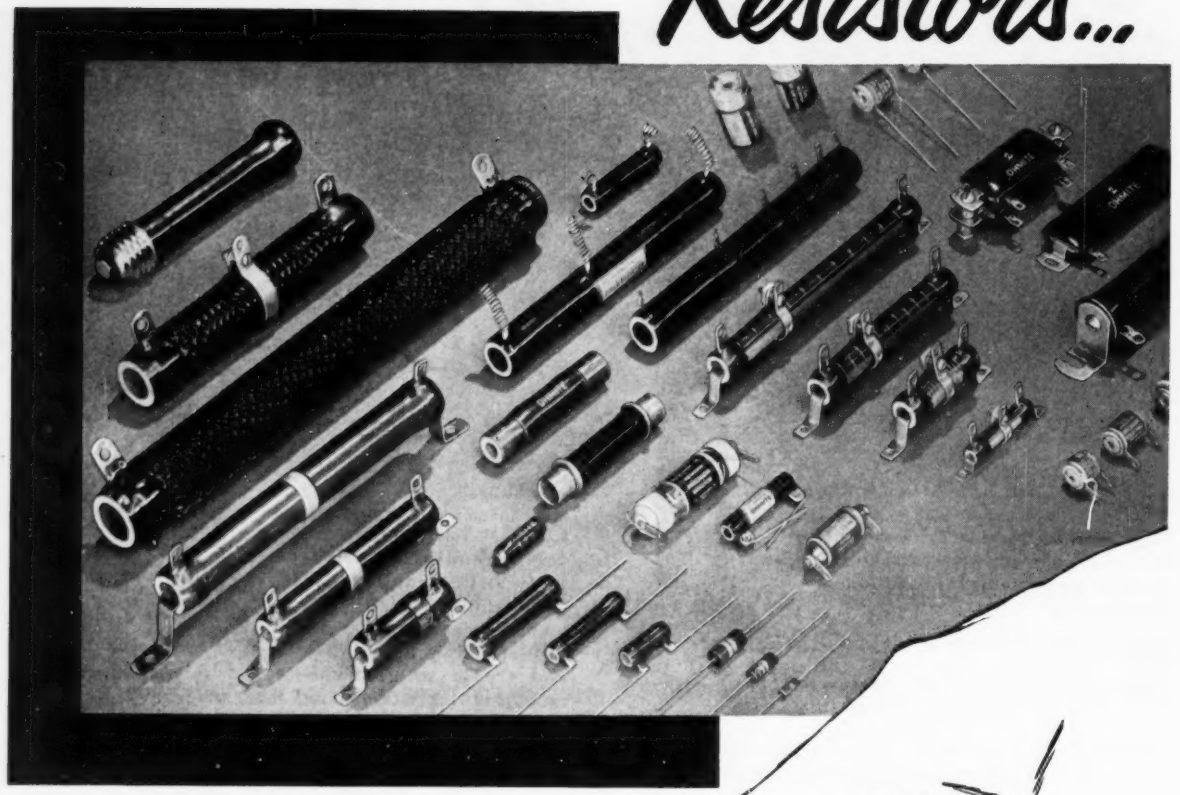
1203 ADAMS STREET, BOSTON 24, MASS., U. S. A.

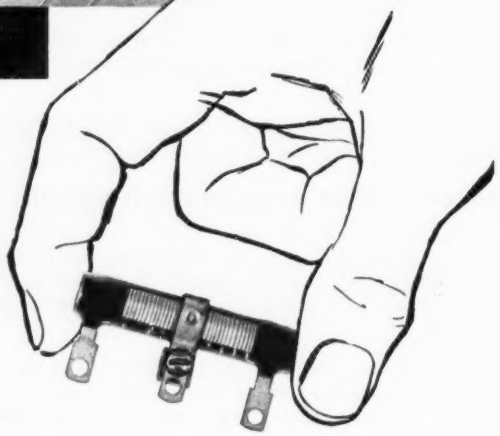
Sales Offices or Distributors in the Following Cities: New York • Syracuse • Chicago • St. Louis • Tulsa • Philadelphia • Houston Pittsburgh • Atlanta • Cleveland • Cincinnati • Detroit • San Francisco • Boise • Louisville • Salt Lake City • El Paso • Albuquerque Charlotte • Los Angeles • Corpus Christi • Denver • Appleton • Birmingham • New Orleans • Dallas • Seattle Mason-Neilan Regulator Co., Ltd., Montreal and Toronto

IN THE PROCESS INDUSTRIES

For more information circle 34 on inquiry card.

OHMITE® *Resistors...*





THE MOST COMPLETE LINE OF WIRE-WOUND RESISTORS ON THE MARKET

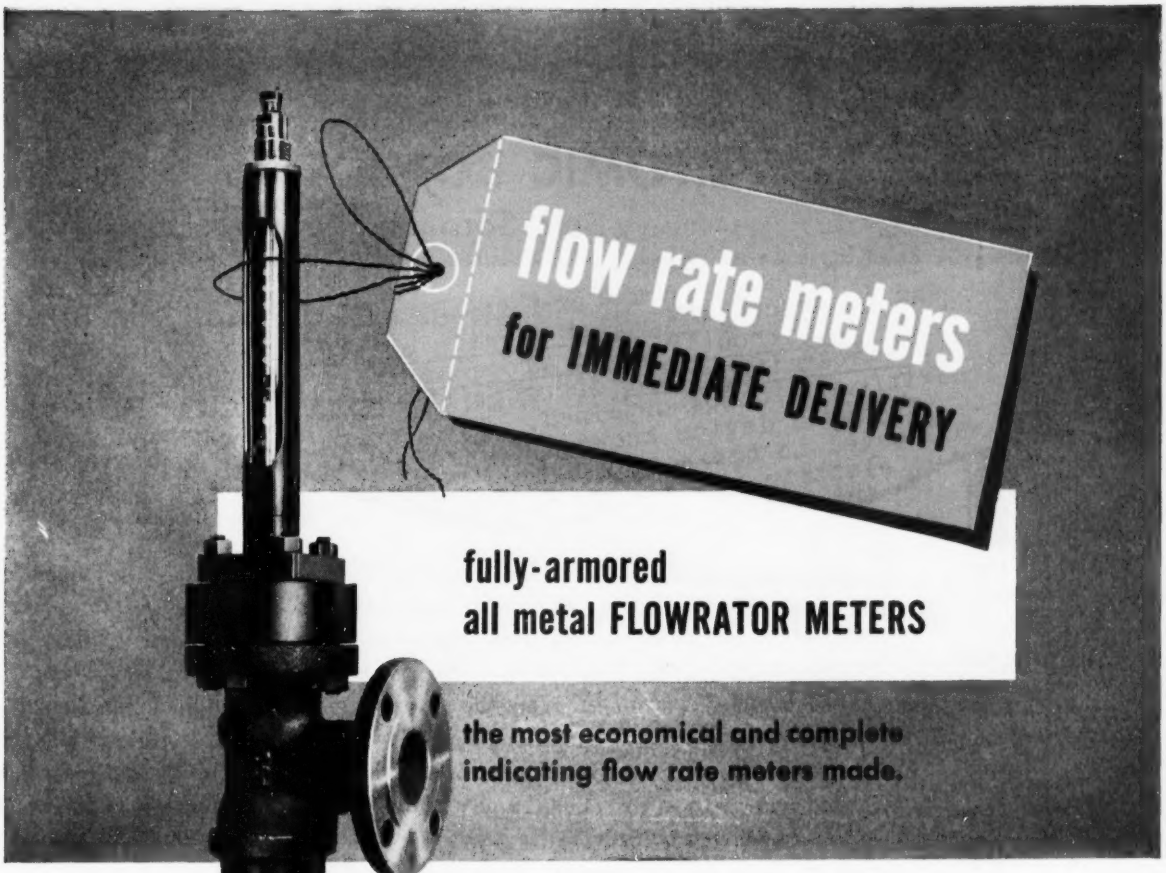
Whatever your resistor needs . . . chances are there's an Ohmite resistor "tailored" exactly to the job. For the Ohmite line includes literally hundreds of units covering a wide range of types and sizes. There are fixed, tapped, adjustable, precision, and non-inductive resistors, with many types of terminals and mountings in a variety of ratings. Regardless of the particular unit *you* need, you are assured of the special design and construction features that have earned Ohmite's reputation for unsurpassed dependability.

OHMITE®

Write on Company Letterhead
for Catalog No. 40
Ohmite Manufacturing Co.
4666 Flournoy Street
Chicago 44, Illinois

FIRST IN WIRE-WOUND RHEOSTATS AND RESISTORS

For more information circle **35** on inquiry card.



fully-armored all metal FLOWRATOR METERS

the most economical and complete indicating flow rate meters made.

With Indicator Extension

With Pneumatic Transmitter

Delivery right from Fischer & Porter stock in Chicago, Dallas, Los Angeles and Hatboro means much to you.

Now you can have the wide range, linear scale Fig. 52 all-metal meter quickly, in 150-lb. and 300-lb. ratings in steel or 316 stainless. These meters are complete meters and not just metering elements, are low in price and may be equipped with Magnabond pneumatic transmitters or all-metal magnetic indicators which are regularly stocked.

Six sizes in FLOWRATOR Meters will cover a capacity range from a fraction of a GPM (or SCFM) to 240 GPM (or 850 SCFM). Each meter, with Stablvis float, has a viscosity immunity well above that found in orifice practice. Write for complete information including Variable Area Handbook.

5 distinct features

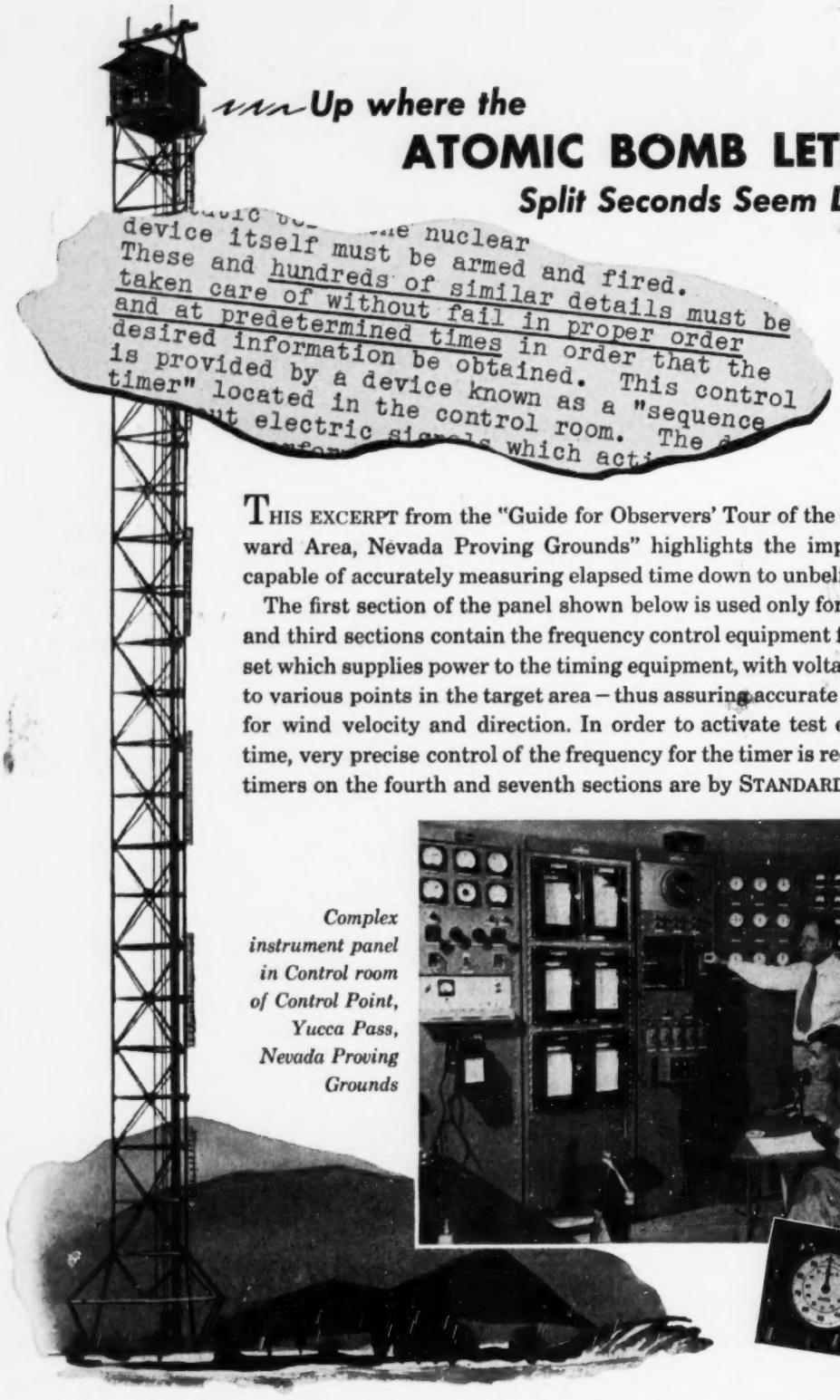
- One moving part, no stuffing box
- Wide rangeability
- Viscosity immunity
- Linear calibration
- Safe, all-metal construction

FISCHER & PORTER CO.

1370 County Line Road, Hatboro, Penn.

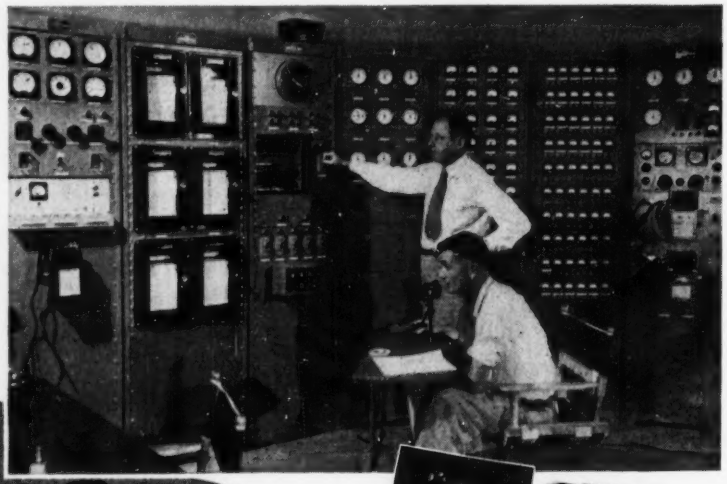
For more information circle 36 on inquiry card.

Up where the
ATOMIC BOMB LETS GO
Split Seconds Seem Like Eternity


nuclear
device itself must be armed and fired.
These and hundreds of similar details must be
taken care of without fail in proper order
and at predetermined times in order that the
desired information be obtained. This control
is provided by a device known as a "sequence
timer" located in the control room. The
electric
which act

THIS EXCERPT from the "Guide for Observers' Tour of the Control Point and Forward Area, Nevada Proving Grounds" highlights the importance of equipment capable of accurately measuring elapsed time down to unbelievably short intervals.

The first section of the panel shown below is used only for air bursts. The second and third sections contain the frequency control equipment for the motor-generator set which supplies power to the timing equipment, with voltage recorders connected to various points in the target area – thus assuring accurate timing – and recorders for wind velocity and direction. In order to activate test equipment at the exact time, very precise control of the frequency for the timer is required... The precision timers on the fourth and seventh sections are by STANDARD.



Complex instrument panel in Control room of Control Point, Yucca Pass, Nevada Proving Grounds

The STANDARD ELECTRIC TIME COMPANY

STANDARD
Since 1884

93 LOGAN STREET • SPRINGFIELD 2, MASSACHUSETTS

PRECISION TIMERS • CHRONO-TACHOMETERS • LABORATORY PANELS • PIPELINE NETWORK ANALYZERS

For more information circle 37 on inquiry card.

TRADE PAPER EDITION
Published by
SCHUTTE and KOERTING
Company

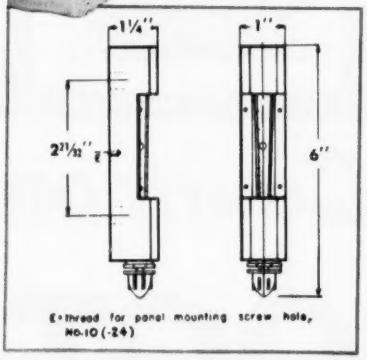
ENGINEERING News

JET APPARATUS • HEAT TRANSFER EQUIPMENT • STRAINERS • CONDENSERS AND VACUUM PUMPS • OIL BURNING EQUIPMENT •

New, Inexpensive SK Purge Rotameters* Indicate and Permit Manual Control of Fluid Flow in Small Quantities

***featuring a back flow check valve and flow control valve**

$13.00 each, net consumer, F. O. B., Cornwells Heights, Bucks County, Pa. In ordering, always state Fig. No., Meter Size, and Scale Marking.



Here's a really new type Rotameter—the SK Fig. 1846CV Purge Rotameter. It's small (weighs ½ lb.) and inexpensive, yet particularly well designed and sturdily constructed with a one-piece body. It is ideal for use in indicating and manually controlling fluid flow in low flow ranges where good reproducibility but only moderate actual metering accuracy are required.

With this small, variable area type flow meter, the rate of flow of fluid passing through the meter is indicated by the position of a ball float moving in a tapered glass meter tube. The rate of flow is read in reference to the center of the ball float on a scale mounted alongside of the meter tube.

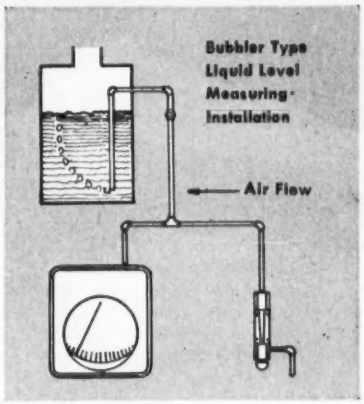
Typical applications include the indication of—

. . . flow of supply air in Bubbler Type Liquid Level Measuring Installations, see drawing.

. . . flow of purge fluid, generally water or air, in the pipelines connecting orifices, venturi tubes, or nozzles to differential head flow meters.

. . . flow of transparent purge fluid to sight glass indicators of Rotameters measuring the flow of opaque fluids.

. . . flow of purge fluid to indicator extensions of indicating Rotameters or to extension wells of Rotameters with electric or pneumatic transmitters where the process fluid carries slurries, tends to settle out crystals, or may form surface coatings.



. . . flow of sample fluid to measuring installations for continuous analysis of fluids.

Special features of the Purge Rotameter include—

. . . a Back Flow Check Valve to positively prevent back flow of process fluid.

. . . a Flow Control Valve for providing sensitive control of fluid flow through the meter over the entire flow range of the meter at differential pressures between 1 to 100 psi across the control valve.

. . . a rigid one-piece meter body which will withstand rough handling in pipe installations and effectively protect the glass tube.

. . . a design particularly suitable for installing directly in pipelines or mounting on instrument panels or in larger instrument cases.

Price, as noted is $13.00 each, net consumer, F.O.B., Cornwells Heights, Bucks County, Pa. Order now.

Meter		Flow Conn.	Rotor Type	Flow Ranges		Pressure Drop	Scale Marking
Type	Size			Water at 70° F	Air at 10 psig & 70° F		
Fig. No.	No.	Inches	No.	gph	cfh	psi	
1846CV	03RZ	⅛ NPT	RB033		.2—2	.8—1	.2—2
	01RZ		RB010	.4—4		1.3—1.5	.4—4
	1RZD		RB10	.1—1** 1—8	.1—2** 2—30	1.5—2	0—10

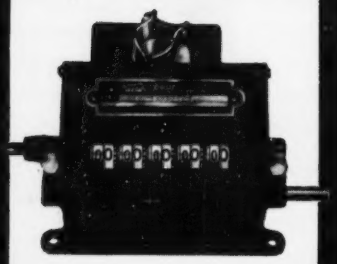
***Note:** Meter and valve bodies are made of anodized aluminum. Control valve shaft is made of stainless steel. Maximum Operating Temperature is 200° F. Maximum Operating Pressure is 200 psig.*

*** The low and high flow ranges are obtained in the lower and upper half of the double taper meter tube respectively.*

SCHUTTE and KOERTING Company
Manufacturing Engineers
136 CORNWELLS HEIGHTS
BUCKS COUNTY, PA.
Representatives in Principal Cities

For more information circle 38 on inquiry card.

You get what you set...



Added Evidence that—

Everyone Can Count on VEEDER-ROOT

Set the predetermining wheels for any run you want. Then, when the counting wheels reach the pre-set number, an electrical contactor makes or breaks the circuit to light a light, ring a bell, or trigger a stop-motion. Yes, this V-R Predetermining Counter is an efficient variable control for *many* types of stop-motion. Short runs and over-runs are prevented on a wide range of machinery, from coil winders to textile looms. Now, figure out how *you* can use this Cost-*Count*rolling Counter. Then write:

VEEDER-ROOT INCORPORATED
"The Name That Counts"
HARTFORD 2, CONNECTICUT
Chicago 6, Ill. • New York 19, N. Y. • Greenville, S. C.
Montreal 2, Canada • Dundee, Scotland
Offices and Agents in Principal Cities

"Counts Everything on Earth"

For more information circle 39 on inquiry card.

Editorial Comment

Dear Reader:

Although the majority of you have already made plans to attend the Eighth National Instrument Exhibit in Chicago (Sept. 21-25), some of you still may be awaiting an invitation.

Instruments is happy to extend each of you an invitation to attend the show and to visit our booth. Please send us your request and we will forward your personal entrance pass to the exhibit.

When Johnny Comes Marching Home

(A letter received from a serviceman with the following address: ER Division, U.S.S. Coral Sea (CVB43), c/o FPO: N. Y., N. Y.)

Dear Sir:

I do not think that this is standard procedure for requesting literature—and this not company stationery. But to rather ease any qualms you may have towards "wasting" literature that you request for distribution, I thought perhaps a word of explanation would be in order.

For three years I worked at American Enka Rayon Corporation, Lowland, Tenn. as an instrument maker. Attended Brown's 13-week training course at Philadelphia and have worked with and around various instruments, such as Bailey, Foxboro, L & N, and Brown. In '51, due to a patriotic urge (and my local draft board's influence) I joined the Navy. Since that time I've attended Electronics Technician School and presently am in the Electronics group aboard ship.

So in order to keep well informed on the industrial electronics field I hope you can see your way clear to forward the literature that I may request occasionally, and also several of the small request cards. I assure you that the literature will probably be better used than if sent to some large company.

I will greatly appreciate your assistance on the above matter.

Another Letter of Interest—with a Message.

Gentlemen:

This letter is not to compliment you on the wonderful new instruments described and advertised so well in your Journal. You and everyone else knows how much you have done to assist in technical advancement.

For years as Electrical Engineer for a Pittsburgh Corporation, when I wrote to one of your advertisers or telephoned to a manufacturer's representative for data or for one instrument for test or use, instant service was rendered; seldom or never had I a complaint.

I retired a few years ago and am now just an individual citizen, and now neither manufacturing companies nor sales representatives will give me information or sell me only one instrument or piece of equipment. This does not apply to high-priced precision instruments, flow meters, ultra range instruments, meggers, micro-wave equipment, recording pyrometers, and dozens of other highly precision instruments. However, let the ordinary citizen try to obtain some standard simple electrical instrument, such as 3-inch ammeter, the answer from the sales representative, electrical supply house, or factory is: "not available." Perhaps you can bring this matter to the attention of the industry.

Perhaps the local supply and distributor house can meet your needs of this type—ed.

On Perspective

WHEN many devices are said to perform the same function, the technical worker is likely to feel confused. However, the many devices can be viewed with proper perspective by realizing that every device has certain applications in which it may excel, but that its superiority in any one respect always is gained at the expense of limitations in other applications.

Today, one hears of many electrical and electronic amplifiers—magnetic, dielectric, electron tube, gas tube, and transistor. Consideration of the regions in which each device finds its optimum use immediately removes the apparent complexity of the subject and leaves the perspective necessary to the proper understanding and use of each amplifier.

The vacuum-tube amplifier is the most common amplifier of small and medium electric currents in electronic circuits. Its frequency response is the highest of the many amplifiers. However, its limitations are inability to handle large currents, relative fragility, requirement for considerable filament and plate power, and some inherent noise.

The gas-tube amplifier overcomes the current-carrying limitations of the vacuum tube, but at the expense of complete control of current by the grid. Also, it has much lower frequency response.

The magnetic amplifier is a controllable inductance through which the maximum current is limited only by the resistance of the wires of the inductor. Thus, thousands of amperes can be controlled. In addition to high current-carrying ability, the advantage of the magnetic amplifier is high ruggedness; however, its frequency response is far below that of electron tubes. Its low inherent noise gives it application in conversion of minute d-c. voltages to a-c. signals in magnetic converters.

The dielectric amplifier, like the magnetic amplifier, is a controllable reactance, and has similar frequency-response limitations that always accompany the use of an a-c. source of power. Like the magnetic amplifier, it is rugged; but it does not have the ability to control currents as large as the magnetic amplifier.

The transistor amplifier overcomes the power-requirement limitations of the vacuum tube, making possible subsubminiaturization of electronic circuits, including the associated resistors and capacitors. Also, it is a solid-state amplifier and hence much more rugged than the electron tube. However, its noise level, power-handling ability, frequency response and temperature stability are less than that of the vacuum tube.

Finally, mention may be made of dynamoelectric amplifiers—too often overlooked by Instrumenticians (see *Handbook of Measurement and Control*, page 50).

Thus it is seen that each device has particular applications in which it excels, and there is little direct competition between various types. So it is with all instruments, and proper perspective is required so that the innate simplicity of each technical device can be appreciated and its optimum use realized.

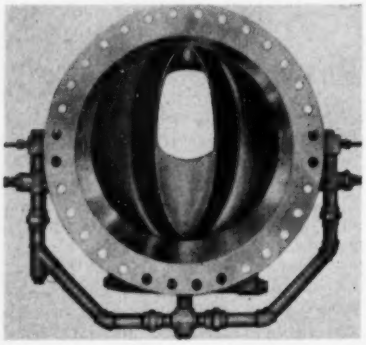
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, computing, metering and automatic control—in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 1067

Self-scouring Venturi Tube

New Type VE Self-Scouring Venturi Tube" has an elliptical throat, was designed to solve problems of accurate measurement of low-velocity



sewage, sludge and trade wastes under low-pressure conditions. Major dimension of elliptical throat is vertical and equal to diameter of circular main section. Hence, a self-scouring flat straight bottom, also a flat top which prevents accumulation of air or gas.—*Simplex Valve & Meter Co., 68th and Upland Sts., Philadelphia 42, Pa.*

For more information circle **201** on inquiry card.

Alarm System

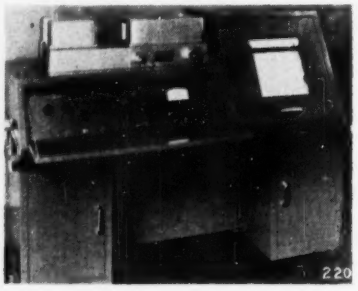
New "ACS Circuit" said to be "the first automatically and continuously self-supervised circuit in the alarm field," automatically signals operator

if alarm system becomes inoperative owing to failure of any component in system itself. This self-policing, plus plug-in design, permits immediate replacement while maintaining process supervision and protection. Moreover, each unit may be used for either normally-open or normally-closed.—*SCAM Corp., 3909 W. Irving Park, Chicago 18, Ill.*

For more information circle **202** on inquiry card.

Mobile Infrared Analyzer

New "Model 14 Automatic Multi-Component Analyzer," for continuous infrared analysis of a pilot plant process stream, monitors concentration of

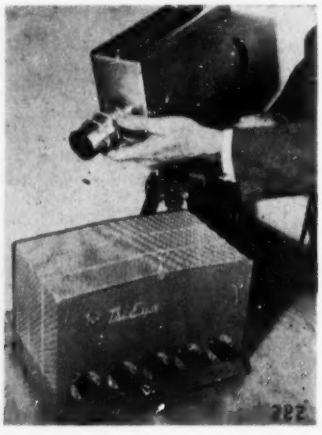


up to six components; plots absorption on a multipoint strip-chart recorder with cycling time of about 6 min.; is mounted in a mobile metal console. Also available on a rental basis.—*The Perkin-Elmer Corporation, Norwalk, Conn.*

For more information circle **203** on inquiry card.

Closed-circuit Television

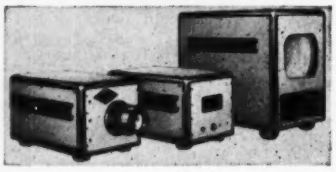
New "TV-Eye" low-price small-size closed-circuit television system is said to make practicable private-line TV for schools, hospitals, small factories,



and even homes; is designed to utilize any standard home-type receiver as a monitor; can be tuned to an otherwise unused channel without interfering with reception on other channels; weighs less than 20 lbs.—*RCA Victor Div., Radio Corp. of America, Camden, N. J.*

For more information circle **204** on inquiry card.

Industrial Television



New "Model 300 B" of maker's "Utiliscope" wired television system incorporates improvements and refinements over original model.—*Diamond Power Specialties Co., Lancaster, Ohio.*

For more information circle **205** on inquiry card.

Contact-type Controller

New model of maker's "Non-indicating Meter-Relay" has sensitivity of 0.2 microamps., 1 percent accuracy and 100-watt load contacts. Can be

used on a.c. with addition of a rectifier; crystal diodes or instrument-type oxide rectifiers are suitable.—*Assembly Products Inc., P. O. Box 191, Chagrin Falls, Ohio.*

For more information circle **206** on inquiry card.

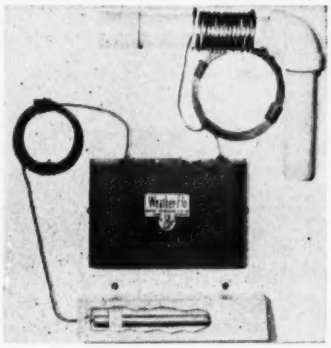
Radio Teletype

New radio teletypewriter system is said to perform with considerably greater accuracy under high noise conditions than presently-used systems; utilizes principles of information theory developed in recent years. Features: (1) use of six different frequencies within bandwidth of radio channel instead of two as presently used; (2) two-pulse code instead of present five-pulse code, whence tripled pulse duration. Effective operating speeds of circuits is reduced while maintaining speed in terms of words per minute.—*Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y.*

For more information circle **207** on inquiry card.

Indoor-outdoor Temperature Controller

New "Weather-Flo" is a simplified form of indoor-outdoor building heat controller. An outdoor thermostatic



bulb resets a system thermostat that changes temperature of water being circulated as outdoor weather changes. —*Automatic Devices Co., Inc., Western Springs, Illinois.*

For more information circle 208 on inquiry card.

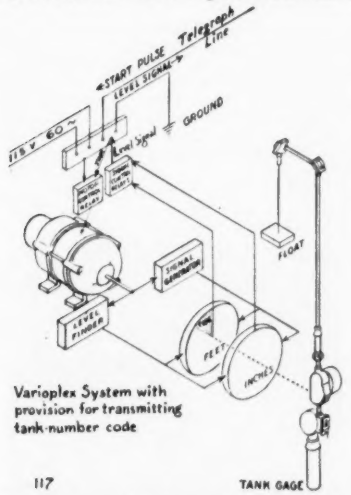
Radio Homing Beacon

New "MO-3975" LF homing beacon transmitter incorporates variable output, is available in a wide variety of combinations. Carrier power is adjustable from 25 to 400 watts by a front-panel-controlled autotransformer. High-level voice modulation is employed, incorporating a peak-limiter to prevent over-modulation. A Type 36 automatic code keyer operates from a phase-shift oscillator at 1020 cps. —*Gates Radio Co., Quincy, Illinois.*

For more information circle 209 on inquiry card.

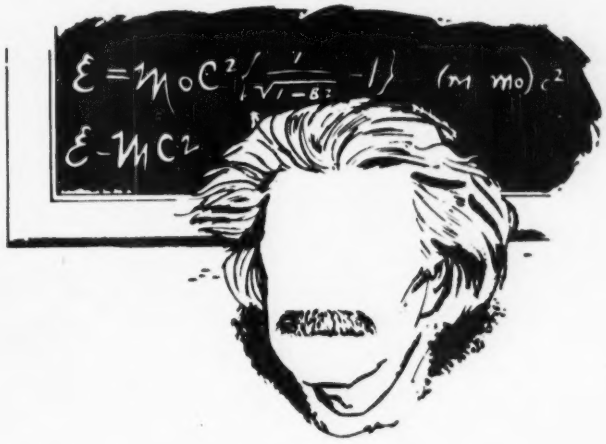
Long-distance Liquid-level Indicating System

New "Varioplex System" permits coast-to-coast transmission of liquid-level readings and individual tank identifications. It comprises standard



Varioplex System with provision for transmitting tank-number code

dial-phone and telegraph components and therefore can be incorporated into existing communication systems of widespread companies, or tied-in with leased wires or radio or microwave services, similarly to Teletype. It is



Some Symbols

become Trade-Marks of Performance

Some Trade-Marks

WELCH DUO-SEAL® PUMPS

become Symbols of Performance

WHEN in 1905 Albert Einstein announced the formula for the energy equivalent of mass, he was subjected to all types of ridicule and criticism. Today scientists throughout the world recognize the validity of his profound calculations and his formula $E = mc^2$.

In 1933 when Welch announced a vacuum pump, made on the new DUO-SEAL principle to produce continuously dependable vacuums to .05 micron, the skeptics were innumerable. Today more than 80% of the world's TV picture tubes are produced with Welch Duo-Seal Pumps.

Write for your free copy of our pump booklet giving performance curves on all DUO-SEAL pumps including special vacuum techniques.

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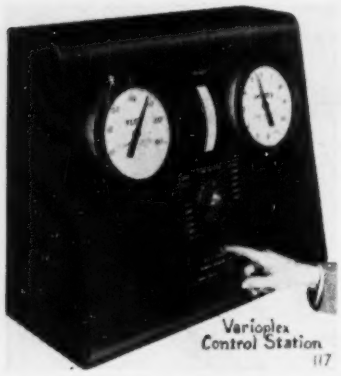
For more information circle 40 on inquiry card.



designed for application to maker's full line of tank gages as produced for many years: to existing S&J gages as well as to new installations.—*Shand & Jurs Co., 8th & Carlton Sts., Berkeley, Calif.*

For more information circle **210** on inquiry card.

Redox Electrodes

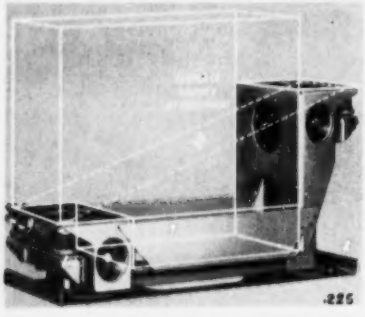
New series of large-area redox-potential metallic electrodes offer broad surfaces of metal—platinum, gold, silver or nickel—mounted in

three basic styles (two illustrated) for all kinds of industrial and laboratory service. Large sensing area assures fast response, minimized polarization effects, easy cleaning and maximum thermal stability. Electrodes will withstand temperatures to boiling or above; can be used with any Beckman pH meter or automatic titrator.—*Beckman Instruments, Inc., South Pasadena 1, Calif.*

For more information circle **211** on inquiry card.

Vibration-control Mount

New "center-of-gravity" type mounting system is engineered to configuration, weight and inertia char-

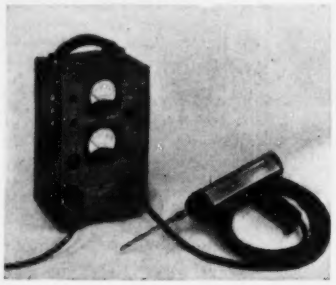


acteristics of protected equipment. "Met-L-Flex" cushions are so located that diagonal plane between top and bottom cushions passes through center of gravity of equipment.—*Robinson Aviation, Inc., Teterboro, N. J.*

For more information circle **212** on inquiry card.

Leak Detector

New "Type H-1" is redesigned halogen-sensitive leak detector. It now has a loudspeaker and an internal voltage stabilizer built into control unit; and an automatic balancing cir-



cuit to compensate for changes in background air contamination. It retains features of former model: earphone plug and instrument indication of leaks.—*General Electric Co., Schenectady 5, N. Y.*

For more information circle **213** on inquiry card.

Liquid Oxygen Transport Container

New 8- to 12-ton capacity liquid oxygen and nitrogen transfer, storage and transport units, designed to operate with a minimum of evaporation loss under all conditions, withstand severe shock loads even when operating in roughest terrain. Semi-trailer comprises liquid oxygen storage vessel and an outer shell which also functions as part of the chassis; vacuum pump to evacuate annular space; electric-motor-driven 150-gpm. centrifugal liquid oxygen pump; valves and safety valves; suitable provisions for precooling pump; atmospheric pressure building coil; modern control board with all instruments accessible.—*Hofman Laboratories, Inc.*, 219-221 *Emmet St., Newark, N. J.*

For more information circle **214** on inquiry card.

Pressurization Controller

New cabin pressure controller weighing less than 3 lbs. combines a cabin pressure selector, a rate-of-change selector and a differential pres-

sure control. It needs no external power source. To complete system, a simple air valve for cabin air discharge is required. Pilot may select cabin altitude between sea level and 10,000 feet and any rate of change for cabin pressure between 100 and 2,000 feet per minute.—*AiResearch Mfg. Co., Los Angeles 45, Calif.*

For more information circle **215** on inquiry card.

Double-range Indicating Millivoltmeter Pyrometer

New single-point double-range indicating millivoltmeter pyrometer, incorporating a newly designed plug-in galvanometer, is said to be more stable in operation, relatively free from effects of vibration and temperature and more easily serviced than earlier types of millivoltmeters. Two combinations of ranges, 0-2400 F. and 0-3000 F., and 0-2000 F. and 0-3000 F. offered as standard; other combinations special.—*Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

For more information circle **216** on inquiry card.

Flush Enclosure for Flame-failure Safeguards

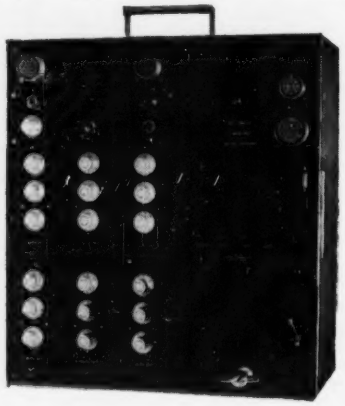
New flush type enclosures for the "26 Series Flame Failure Safeguard Controls" are included in "Fireye" flame safeguard systems "FP-2" and

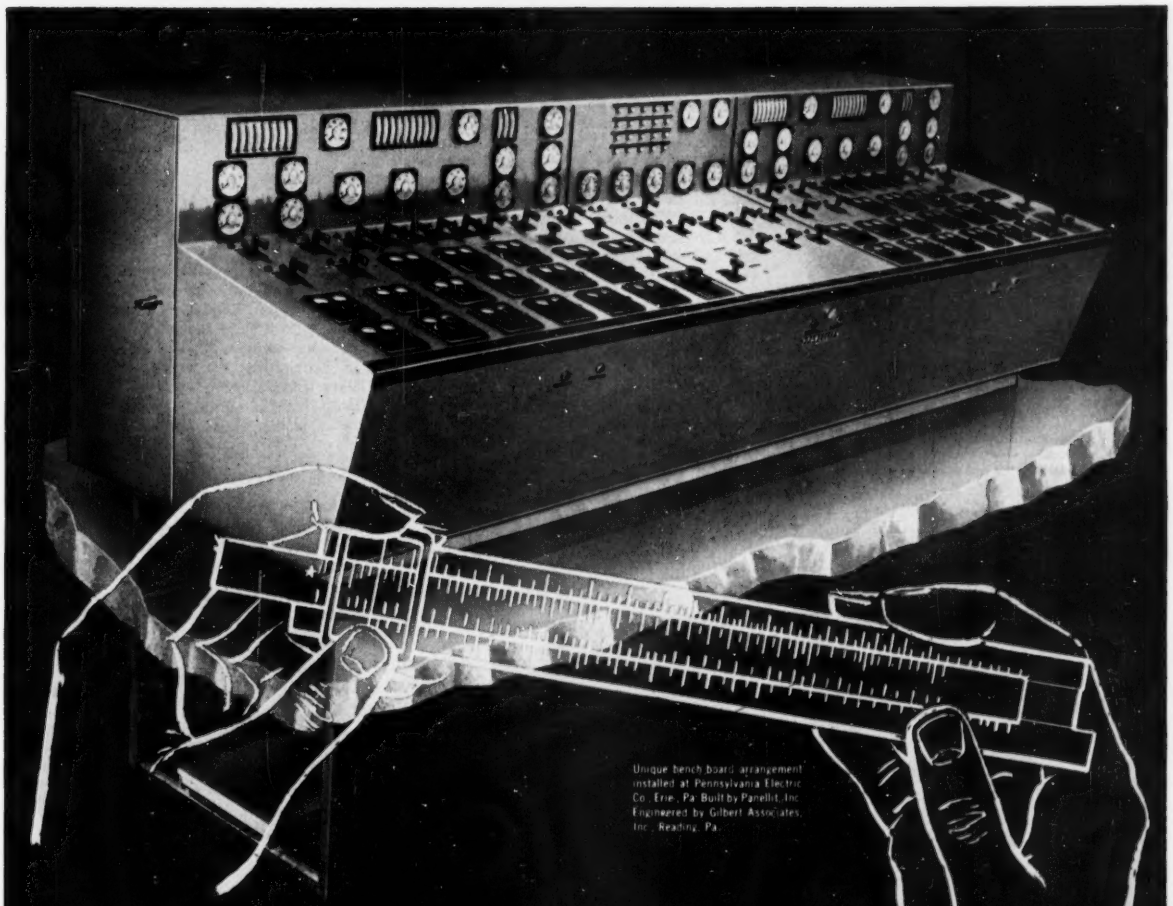
"FP-4" for both automatic and manually fired burners of all types.—*Combustion Control Corp.*, 718 *Beacon St., Boston 15, Mass.*

For more information circle **217** on inquiry card.

Refraction Seismograph Equipment

New "PRA-1 Portable Amplifier-Recorder," for refraction seismograph operation is available for either six- or twelve-trace operation. Individual amplifier channels are of plug-in type; each has four stages of amplification and one *L/C* section of high-cut filtering. Frequency response is 3 to 200





Unique bench board arrangement installed at Pennsylvania Electric Co., Erie, Pa. Built by Panellit, Inc. Engineered by Gilbert Associates, Inc., Reading, Pa.

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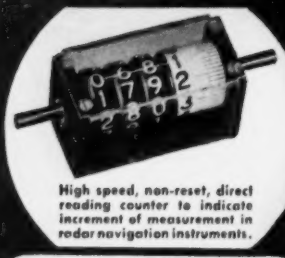
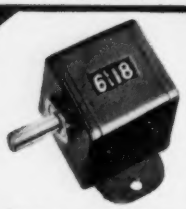
For more information circle 41 on inquiry card.

DURANT
MFG. CO.
Specials
For RADAR, ELECTRONIC and INSTRUMENT APPLICATIONS

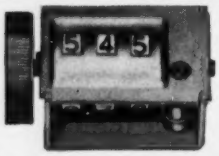


High speed, non-reset, direct reading counter to indicate increment of measurement in radar navigation instruments.

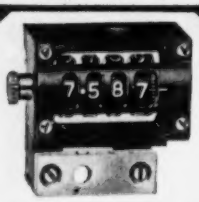
High speed degree-type counter to indicate degrees, minutes and tenths of minutes for navigating equipment.



"Y" 2-figure Rotary Counter used in navigating instruments.



Special counter for use on Tape Recorder to indicate the position of tape passing through the recorder.



Special high speed Y-type counter for Goniometer application.

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114 Orange Street, Providence 3, R. I.

PRODUCTIMETERS
SINCE 1879 *Count Everything*

For more information circle 42 on inquiry card.

NEW INSTRUMENTS

cps. A 10 microvolt input signal will result in 2.25 inches of galvo deflection using "Type C" galvanometer. Recording oscillograph timing system has precision temperature-compensated fork; 4-in. photographic paper is driven by a governor-controlled motor. Portable equipment supplied with "PRA-1" includes a blaster, seismic detectors, power supply, and daylight developer.—*Electro-Technical Labs., Inc.*, 504 *Waugh Drive, Houston* 19, *Texas.*

For more information circle 218 on inquiry card.

Surveyors' Levels

New feature of maker's levels is a variable-power eyepiece, which obviates need for more than one eyepiece for changes of magnification, and gives a clear, flat field, devoid of aberrations, at any magnification selected. Two eyepiece caps are supplied, one incorporates a haze filter, useful for making long sights under adverse conditions.—*W. & L. E. Gurley, Troy, N. Y.*

For more information circle 219 on inquiry card.

TV Camera Dolly

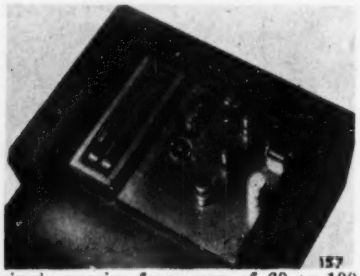
New pneumatic-balanced 3-wheel camera dolly for television studio use allows camera operator to raise or lower camera with practically no effort in a smooth, cushioned motion.—*Television Transmitter Div., Allen B. Du Mont Labs, Inc.*, 1500 *Main Ave., Clifton, N. J.*

For more information circle 220 on inquiry card.

TIME, SPEED AND COUNTING

Frequency Standards

New "Cenco-Riverbank Frequency Standards" provide frequency stability over temperature range from —20 C. to 75 C. Stock models provide a

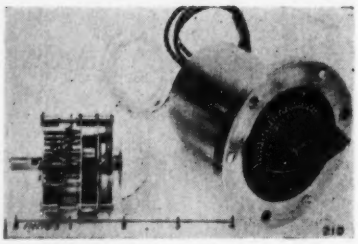


single precise frequency of 60 or 100 cps. with a tuning accuracy of 0.003 percent. Models for other frequencies are available.—*Central Scientific Co.*, 1700 *Irving Park Road, Chicago* 13, *Ill.*

For more information circle 221 on inquiry card.

Automatic Timer

New spring-driven hermetically-sealed automatic timer was developed as guided-missile equipment but has commercial applications. Interval, preset at any point between 1 to 30 seconds, starts by a mechanical inertia switch operating when acceleration of 3 to 4 *G* is obtained during launching. At end of preset interval, timer closes

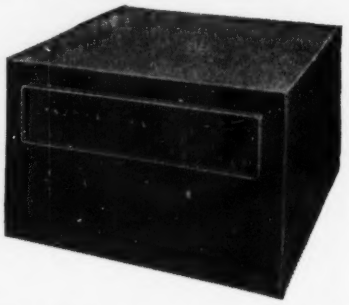


a switch in missile electrical system. Unit functions through temperature range from —50 C. to 80 C.; altitude to 70,000 ft.; will withstand 30 *G* in any axis with maximum of 50 *G* in launching direction.—*Masco Products Co.*, 2119 *Sepulveda Blvd., Los Angeles* 25, *Calif.*

For more information circle 222 on inquiry card.

Electronic Tachometer

New "Electronic Tachometer" measures speed, frequency, or events per unit of time; features use of a new cold-cathode-glow transfer tube

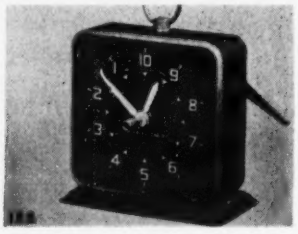


to give a clear read-out. Accuracy of time base is one part per million; power requirement is 100 watts; size is 12 x 8 x 12 in. For ease of servicing when required, instrument has 11 plug-in sub chassis, 22 vacuum tubes, and 7 plug-in counter tubes.—*Dep't 208, Standard Electric Time Co., Springfield* 2, *Mass.*

For more information circle 223 on inquiry card.

Interval Timer

New "Solar" interval timer has large dial reading 1-min. to 10-min. intervals with 15-sec. divisions; inner

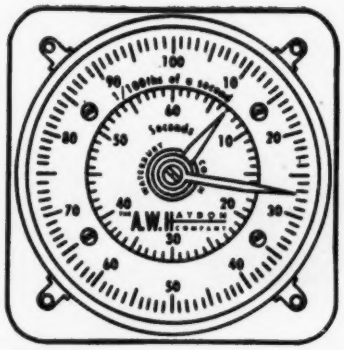


dial divided into 10-min. intervals to 120 min.—*Burke and James Inc.*, 321 *S. Wabash Ave., Chicago* 4, *Ill.*

For more information circle 224 on inquiry card.

Stop Clock

New hermetically-sealed high-speed stop clock totalizes hundredths of a second up to a minute; is available with automatic reset and accrued seconds indicator with fluorescent dial



and hand; is also available for other intervals; for operation on 50-, 60-, or 400-cps. ac. or 20-30 v.dc. and 400-cps units that have dc. clutch.—*A. W. Haydon Co.*, 232 *Elm St., Waterbury* 20, *Conn.*

For more information circle **225** on inquiry card.

Engine Running-time Meter

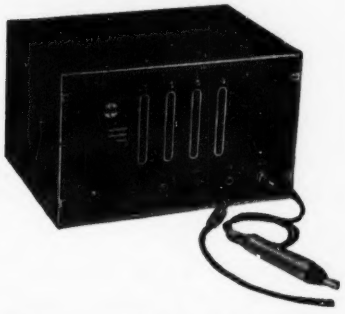
New "D.C. Hour Log" tells how long a portable or stationary engine has been operating, thus eliminating

too frequent or too little servicing.—*Engler Instrument Co.*, 250 *Culver Avenue, Jersey City, N. J.*

For more information circle **226** on inquiry card.

Sheet Counter

New sheet counter, for printers and others requiring an exact count of sheets or boards 0.003 in. or more in thickness, counts several thousand



sheets per second. A quick zip of a hand-held probe, down the sloping edge of a fanned stack of sheets of paper or board, produces an illuminated total in red numerals on four counting decades (up to 9,999). Normal reset, after each sweep of probe, either by a push-button switch on panel, or by a foot switch. Probe is a permanent-magnet reluctance-type displacement pickup whose output is amplified and shaped to provide a

Made to measure . . .

The Gaumont-Kalee Flutter Meter is an instrument designed to measure small deviations from constant speed occurring in sound recording and/or reproducing machines. Consisting of a narrow band amplifier, a limiter, a discriminator and detector, and a metering system, the whole unit is self-contained with its own power supplies.

The instrument responds down to zero frequency and will therefore indicate accurately the lowest wow components present. The power consumption is 100 watts and the main characteristics of the instrument may be summarised as follows:

Operating carrier frequency	3,000 c.p.s. ± 5%
Minimum input signal	100 mV
Input impedance	0.5 megohm
Input amplifier band width	— 2db at 2,500 and 3,500 c.p.s.
Effective limiter range	5:1
Peak wow meter F.S.D.	± 1% peak (centre zero)
R.M.S. Meters F.S.D.	1.0% R.M.S.
R.M.S. Meters F.S.D. on divide by 5 range	0.2% R.M.S.
Cross over frequency	20 c.p.s. ± 10%
Flutter meter response	— 3db at cross over — 2db at 200 c.p.s. — 8db at 300 c.p.s.
Wow meter response	— 3db at cross over — 1db at ½ c.p.s.
C.R.O. Output frequency	Level down to zero frequency — 2db at 200 c.p.s.
C.R.O. Max. output signal	150 V peak to peak
Analyser output frequency response	— 2db at 400 c.p.s. — 1db at ½ c.p.s.
Analyser output for 1% peak to peak deviation	3 volts R.M.S. approx.
Analyser output must be closed upon 0.5 megohms.	
All meter presentations, accuracy ± 5% of F.S.D.	

GAUMONT-KALEE *flutter* **meter**
TYPE 564

Full details of this equipment may be obtained from The Studio Dept.

G.B-KALEE LTD. Mortimer House, 37-41 Mortimer St., London, W.1 Cables: Gebekay, London

A Member of the British Optical & Precision Engineers' Group

For more information circle **43** on inquiry card.

Atkomatic Solenoid Electric Valves are available in sizes from ¼ inch to 3 inches, and for pressures to 3,000 psi. Adjustable timing on the closing stroke is available on all valves up to pressures of 300 psi.

Designed with only three moving parts and no external linkage, wear and maintenance are greatly reduced. Availability for normally opened or normally closed operation makes it possible for the valve to fail safe in the event of power failure.

Atkomatic Solenoid Electric Valves are made with standard coils of paper insulation, vacuum impregnated and baked for resistance to moisture, or glass-insulated coils for higher temperatures.

Write for more complete information

For all your Solenoid Electric Valve Requirements, Look to . . .

Atkomatic

SOLENOID

ELECTRIC

VALVES

ATKOMATIC VALVE COMPANY
525 Abbott Street · Indianapolis 25, Indiana

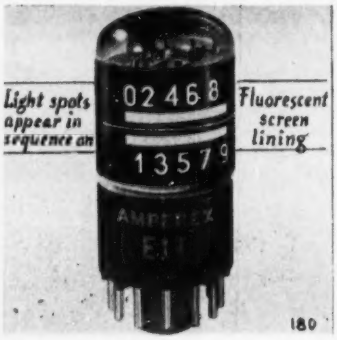
For more information circle **44** on inquiry card.

proper input signal to first decade. Decade counting units are interchangeable and plug-in, are premutated binary counters provided with a resistor matrix to give decimal indication on neon lamps.—*Ultrasonics, Inc., Ferguson, Mo.*

For more information circle **227** on inquiry card.

Decade Counter Tube

New "Vidicount-E1T" is a cathode-ray type tube which serves as a scale of ten, permitting elimination of a number of tubes and components com-



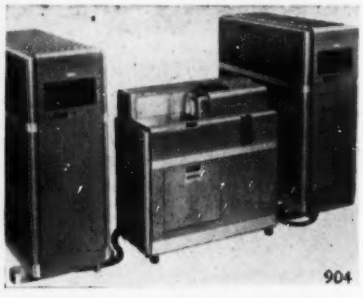
monly used in decade circuits (and corresponding reduction in power requirements). According to number of counting pulses applied, tube's ribbon-shaped electron beam passes in succession through ten apertures of a cylindrical anode and impinges on a fluorescent screen, so that rectangular luminescent spots corresponding to number of pulses can be read opposite figures 0 to 9. As last position is passed, beam resets to zero and a counting pulse is applied to following tube. With several "E1T" tubes in cascade, any integer can be read directly.—*Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L. I., N. Y.*

For more information circle **228** on inquiry card.

COMPUTING

Electronic Calculator

New electronic calculator for use in business and industry will handle up to 140 instructions for each computa-

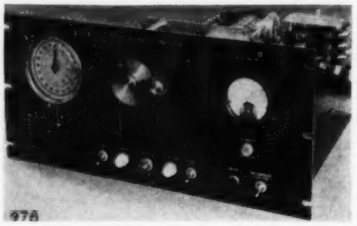


tion and up to 6,000 computations an hour.—*International Business Machines Corp., 590 Madison Ave., New York 22, N. Y.*

For more information circle **229** on inquiry card.

Analog Computer

New "Recording Counting Rate Computer," designed to record random counting rates on a linear chart with a constant computed statistical accuracy, makes use of Ohm's Law



as analog to basic counting equation ($nT = N$, n = counting rate, T = time interval, N = total number of counts). A slidewire resistor is driven by a synchronous motor so that resistance in circuit is proportional to time. With fixed battery voltage, current recorded is proportional to counting rate. New computer must be used with a scaling circuit adjusted for fixed count operation: range is controlled by choice of scale factor and the speed with which slidewire is driven (adjusted by range gears). Chassis layout provides for easy addition of an accessory pulse generator if this is desired at a later date.—*Research & Control Instruments Div., North American Philips Co., Inc., 750 S. Fulton Ave., Mount Vernon, N.Y.*

For more information circle **230** on inquiry card.

Computer-tape Mechanism

New computer magnetic tape mechanism for recording and storage of digital data comprises all elements needed for high-speed handling of half-inch magnetic recording tape; may be operated automatically by pulsed input signals, or controlled manually by a front panel switch. It moves from stop to start or vice versa in less than five milliseconds. Magnetic head has six channels, narrow gap, with h-f. response; can be readily removed or interchanged. A photo reading head detects printed markings on back of tape. Automatic tension control has already proved itself in the RAYDAC. Factory adjustments can be slightly modified in field if necessary. Reel assembly features two 1000-foot reels mounted side-by-side on coaxially-driven shafts with two reel motors, gear drives, and tachometers. Extra idler can be set to provide variations in wrap of tape about magnetic heads. Sponge rubber cushion covered with lens tissues cleans magnetic surface of tape.—*Raytheon Mfg. Co., Waltham 54, Mass.*

For more information circle **231** on inquiry card.

Magnetic Tape Handler

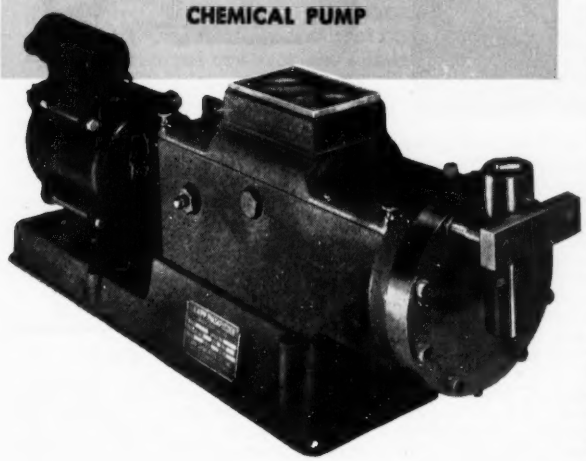
New high-speed low-cost magnetic tape handler for digital data handling and general computer recording and playback has unique feature: ability to start and stop intermittently within 5 milliseconds from external signals, thus making it possible to record, playback, or compare blocks of information. Reversible drive speeds, 15 and 30 in. per second. New photoelectric proportional servo tension control at all speeds; no tape breakage or spilling on quick reverses. Two models are in production: "901A" for 0.5-in. tape,

THESE FLUIDS ARE DIFFICULT TO PUMP

ACETALDEHYDE
ACETONE
FORMALDEHYDE
FREON
MERCAPTANS
MERCURY
MOLTEN METALS
NAPHTHALENE (Molten)
NITRIC ACID
PHOSPHORIC ACID
SODIUM CYANIDE
SULFUR DIOXIDE
TRINITROCHLOROBENZENE
VINYLIDENE CHLORIDE
CHLOROSULFONIC ACID
CHROMIC ACID
HYDROBROMIC ACID
NITRIC ACID
OLEUM
OXALIC ACID
PROPIONIC ACID
SULFURIC ACID
IODINE
BENZOLCHLORIDE
BENZOLTRICHLORIDE
LIQUID BROMINE
CHLORACETIC ACID
DILUTE ACIDS
ALUMINUM SULFATE
DIATOMACEOUS EARTH SLURRY
FERRIC SULFATE
SODIUM HYPOCHLORITE
SALT SOLUTIONS
SODIUM SILICOFLUORIDE
HYDROGEN PEROXIDE
HYDROCHLORIC ACID
BROMINE TRIFLUORIDE
CHLORINE
CHLORINE TRIFLUORIDE
FLUORINE GAS
HYDROFLUORIC ACID
HYDROGEN CYANIDE
HYDROGEN FLUORIDE
FLUORINE
SULFUR DICHLORIDE

THEY ARE HANDLED SUCCESSFULLY BY THE Lapp PULSAFEEDER

PISTON-DIAPHRAGM CONTROLLED-VOLUME CHEMICAL PUMP



Not competitive with any pump of more conventional design, the Lapp PULSAFEEDER is a highly specialized, precision, custom-built machine suited to a wide variety of special applications involving controlled-volume pumping of fluids.

Basic feature of Lapp PULSAFEEDER design is its combination of reciprocating piston action (to provide the accuracy of positive displacement) with an hydraulically balanced diaphragm which isolates material being pumped from working pump parts—and, of course, eliminates need for stuffing box or running seal.

Control of pumping rate is achieved at constant pumping speed; variable flow results from variation in piston stroke length—adjustable by hand-wheel, or, in Auto-Pneumatic models, by instrument air pressure responding to any instrument-measureable processing variable.

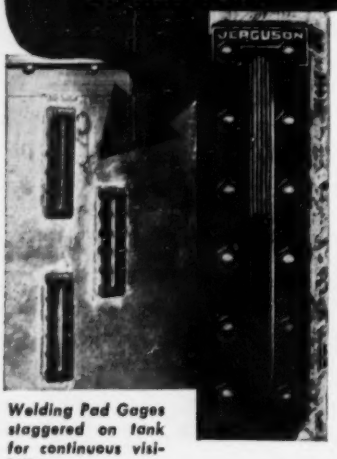
Justification for this specialized premium construction is evident in the many, and varied, applications in which Lapp PULSAFEEDER alone is able to perform satisfactorily. In fact, the economies of continuous processing, automatic proportioning, feeding and filling in many operations are possible only because of the unusual characteristics and peculiar advantages of Lapp PULSAFEEDER.

In general, use of the Lapp PULSAFEEDER is indicated for continuous (or intermittent) pumping, at accurately controlled volume, of fluids which cannot be satisfactorily exposed to conventional pistons, cylinders and stuffing box packing—because of the corrosive action of chemicals being handled and/or need for protection of product against contamination.

Lapp Bulletin 300 shows typical applications and flow charts. It describes and lists specifications of models over a wide range of capacities and special constructions. Also included is an Inquiry Data Sheet, from which we can make specific engineering recommendations for your processing requirement. For your copy write Lapp Insulator Co., Inc., Process Equipment Div., 120 Wilson St., Le Roy, N.Y.

For more information circle 45 on inquiry card.

SPECIAL
JERGUSON
WELDING PAD GAGES
are integral part
of this tank



Welding Pad Gages staggered on tank for continuous visibility.

HERE is a special line of gages that weld right to the liquid containing structure, thus becoming an integral part of it. It solves problems where it is impractical for you to use a conventional type gage because of solids in suspension in a liquid, etc.

These Special Gages follow Jerguson Standard Gages in general design and materials, except for the method of attaching. The chamber of the gage consists of a bar steel pad which is welded to the vessel.

Welding Pad Gages are made in both Reflex and Transparent types . . . in all sizes of Jerguson Standard Gages. Pressure ratings are available to your specific requirements. Welding pad may be of any metal desired to withstand corrosive or other conditions.

Write for Data Unit on Welding Pad Gages for complete details. Whatever your gage problems, let Jerguson engineers assist you.

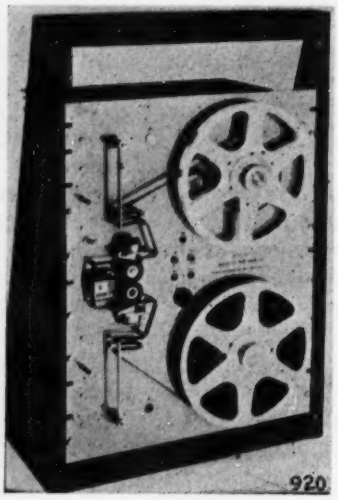
JERGUSON

Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY
100 Fellsway, Somerville 45, Mass.
Offices in Major Cities
Jerguson Tress Gage & Valve Co., Ltd., London, Eng.
Pétrole Service, Paris, France

For more information circle **46** on inquiry card.

NEW INSTRUMENTS

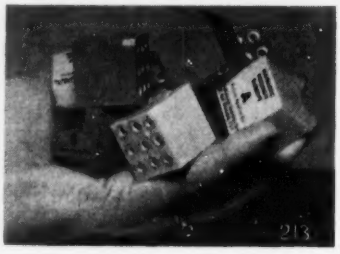


six-track recording; "901B" for 0.25-in. tape, two tracks. (other models, one to eleven tracks).—*Potter Instrument Co., Inc., Great Neck, N. Y.*

For more information circle **232** on inquiry card.

Basic Elements for Digital Computers

New "Magnetic Decision Elements" are fundamental building-blocks for digital computing structures. They incorporate the functions of decision (switching, gating, mixing, etc.), stor-



age, power gain, and pulse-shaping. There are two standard types ("S" and "A") with which it is possible to build the entire arithmetic, program, control and memory sections of any digital computer, both serial and parallel systems. Standard elements are one cubic inch, designed with Hubbell interlock connectors for rapid cascading in any desired performance pattern. They contain no electron tubes or transistors. All components are cast in epoxy and units operate reliably over ranges of temperature, humidity, vibration and shock encountered in military applications. Synchronization and power drive derived from a central 200-kc. two-phase clock pulse generator; and rate of information flow is 100 kc. Static storage in each element makes it possible to turn power off at any time with suitable clock switching facilities and retain all information in the machine indefinitely, including dynamic arithmetic operations.—*Minnesota Electronics Corp., St. Paul, Minn.*

For more information circle **233** on inquiry card.

LIQUID LEVEL

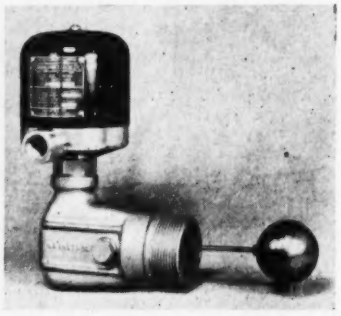
Liquid-level Controller

New "Model A-100" liquid-level controller uses, in place of conventional floats, displacers made of porcelain, neoprene or karbate, whose distance apart determines amount of liquid travel between switch "make" and "break." Displacers sink and thereby overcome effects of surging or swirling. Differentials up to 100 feet are possible. "Model A-100" is available as a "tandem" unit with two switches for separate high and low level action, and in trims to suit almost any type of liquid.—*Magnetrol, Inc., 2110 S. Marshall Blvd., Chicago 23, Ill.*

For more information circle **234** on inquiry card.

Float Switch

New "Model TF-63" float switch screws into side of tank ("Model TF-52" mounts by flange). It is suitable for (1) high or (2) low level alarm;



(3) pump control; (4) high and low level alarm, etc. Differentials from 0.75 in. to 15.5 in., depending upon length of float stem. Both "TF-63" and "TF-52" are available as "tandem" units, with two switches for separate high and low signal.—*Magnetrol, Inc., 2110 S. Marshall Ave., Chicago 23, Ill.*

For more information circle **235** on inquiry card.

PHOTOGRAPHY

High-speed Film

New "Super-Tomic" high-speed film, said to be faster than any comparable film on market, is available in color and black-and-white. "Super-Tomic S/125" color film comes in 35mm. size and carries an exposure index of 125 daylight, thereby making possible color shots under light conditions impossible with other available color film: desirable for use in many industrial, scientific, and medical applications. "Super-Tomic U/250" panchromatic black-and-white film has exposure index of 250 daylight and 160 tungsten. An absolute minimum

Do you have a "Problem" Fluid to be metered?

Many highly corrosive or viscous fluids previously considered unmeasurable are now accurately and easily metered with Foxboro d/p Cell. The wide acceptance and successful performance of this all-metal flow transmitter are indicated by more than 17,000 successful installations.

Simpler, less expensive to install and maintain, the d/p Cell measures the flow of "problem fluids" as easily as water, steam, or air . . . transmits pneumatically or electronically to indicating, recording, or controlling receivers. Small, compact, and mercuryless, the d/p Cell weighs less than 19 lbs. Its negligible displacement and corrosion-proof construction eliminate usual maintenance problems. Ranges: from 25" to 800" water. Working pressures to 4000 psi. Steel or Type 316 Stainless construction, or other materials as required.

If you have a difficult flow measuring problem, let us show you how the d/p Cell can solve it.

Fluids like these are no problem for d/p Cells

Liquid Latex
HCL Acid
HNO_3 Acid
HF Acid
H_2SO_4
Molten Naphthalene
Molten Phthalic Anhydride
Molten NaCL
Molten Sulphur
Raw Sewage
16% Lime Slurries
4% Paper Stock
Chlorine (gas or liquid)
Molasses
Any condensable fluid, no condensing chambers needed

THE FOXBORO COMPANY, 466 NEPONSET AVE., FOXBORO, MASS., U.S.A.

FOXBORO REG. U.S. PAT. OFF. d/p cell

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

For more information circle 47 on inquiry card.

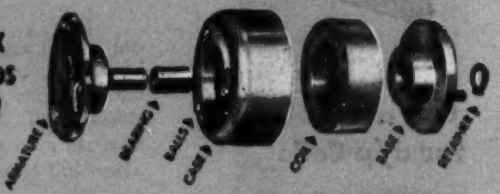
LEDEX ROTARY SOLENOIDS

...give positive, powerful snap action!

here's how a LEDEX ROTARY SOLENOID operates...

The magnetic pull moves the armature along the Solenoid axis. This action is efficiently converted into a rotary motion by means of ball bearings on inclined races. The inclined ball races are made to compensate for the magnetic pull increase as the Solenoid air gap closes, thereby providing substantially constant torque throughout the Solenoid stroke. The rotary snap-action power of the Ledex can be efficiently harnessed with a minimum of linkages, through the use of one or more standard features available on all models.

here's why LEDEX ROTARY SOLENOIDS are dependable!



As can be seen from the exploded view, Ledex Rotary Solenoids are simply constructed with few moving parts. All parts are manufactured to exacting tolerances and are carefully inspected and assembled.

The copper wire coil, the heart of the Solenoid, was developed especially for this product. It is wound by a precision winding process that puts a maximum amount of magnet wire into available space . . . giving tremendous power to compact Ledex Rotary Solenoids.

six basic LEDEX ROTARY SOLENOIDS to choose from!

Model Number	2	3	5	6	7	8
Diameter	1 1/16"	1 5/16"	1 7/8"	2 1/4"	2 3/4"	3 1/8"
Torque lb.-in.*	1/8	1	5	10	25	50
Weight lbs.	1/8	1/4	1/2	1	2 1/4	4 1/4

*45° stroke intermittent duty.

Engineering data is available upon request. Write for descriptive literature today!

J. H. Leland INC.

123 WEBSTER STREET, DAYTON 2, OHIO

of grain allows for blow-ups of even a small portion of a 35-mm. frame. —*Super-Tomic Products Co.*, 6411 *Hollywood Blvd., Hollywood* 28, *Calif.*

For more information circle 236 on inquiry card.

High-resolution Photographic Plates

New High Resolution photographic plates are specifically designed for production of extremely fine line images; are offered in sizes from 1x3-in. to 8x10-in.; can be used with suitable optics to produce reticles where resolving powers of the order of 1,000 lines/mm. are required.—*Eastman Kodak Co., Rochester* 4, *N. Y.*

For more information circle 237 on inquiry card.

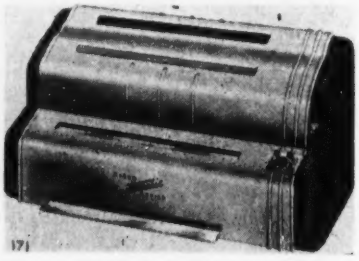
Camera-tripod Attachment

New "Elepod" all-purpose attachment fits all tripods, holds camera in almost every conceivable position above, below, at side, etc.; maximum extension 14 inches.—*Burke and James Inc.*, 321 *S. Wabash Ave., Chicago* 4, *Ill.*

For more information circle 238 on inquiry card.

Photocopying Machine

New "Apeco Systematic Auto-Stat," said to be "a complete photocopying department in a single compact cabinet," obviates need of a dark-



room; utilizes a beltless principle of operation with two different types of paper, both coated with special emulsion developed by makers of unit. Original to be copied is fed through exposure slot with a sheet of No. 1 paper; No. 1 and No. 2 papers are then passed together through Auto-Stat portion; operator then peels sheets apart: "two steps instead of 12 required by conventional photocopy equipment." A finished copy can be made in less than 30 seconds. Size capacity, 11 x 17 inches. Original may be printed on one or both sides or on opaque or translucent paper.—*Photocopy Equipment Co.*, 2849 *N. Clark St., Chicago* 14, *Illinois.*

For more information circle 239 on inquiry card.

FOR THE LABORATORY

High-pH Lovibond Disk

New "No. BDH 1014" disk for Lovibond Comparator covers pH range 10.0 to 14.0. It is stated that heretofore no comparator test has been available for these high alkaline values, because no stable and reproducible indicator could be produced. New disk's color changes are definite,

For more information circle 48 on inquiry card.

ranging from green through grey to orange-red. Their accuracy has been checked against hydrogen electrode readings.—*Curry & Paxton, Inc.*, 101 *Park Ave., New York* 17, *N. Y.*

For more information circle 240 on inquiry card.

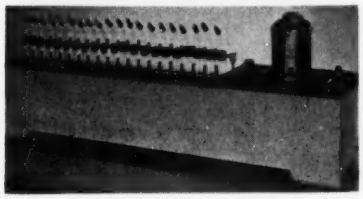
Short-range pH Papers

New kit of six "short-range" indicating papers divide entire pH scale of 0 to 14 into distinctive colors for each half unit; and permit estimations to one-fourth unit or closer; are matched while wet with color key printed on a plastic dispenser.—*Fisher Scientific Co.*, 717 *Forbes St., Pittsburgh* 19, *Pa.*

For more information circle 241 on inquiry card.

Oil Stability Apparatus

New model of maker's "Fat Stability Apparatus" for determination of relative keeping quality of lards, fats and oils, provides higher oper-



ating temperatures with consequent reduction of test time and easier assembly of air distribution system. Circulation of electrically-heated mineral oil bath is accomplished by an immersed centrifugal pump. Temperature may be adjusted over 95-115 C. range with regulation to 0.1 C. Suspended cover rack accomodates twenty aeration tubes.—*E. H. Sargent & Co.*, 4647 *W. Foster Ave., Chicago* 30, *Ill.*

For more information circle 242 on inquiry card.

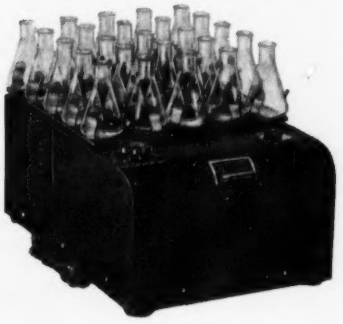
Fume-hood Top

New "Unitized Fume Hood," with 30-in. Kemstone top specified, adds about 30 percent to present working depth; is available from stock with either a drawer-cupboard base or cupboard base. Kemstone top, in a single sheet 47.06 x 30 x 1.25 in. thick, to be installed by user, is available separately.—*Fisher Scientific Co.*, 717 *Forbes St., Pittsburgh* 19, *Pa.*

For more information circle 243 on inquiry card.

Laboratory Shaker

New "Model S-3 Gyrotory Shaker" occupies 16x23-in. bench space, handles glassware from 50 ml. to 500 ml., Erlenmeyer flasks, test tubes, petri dishes, slides etc. Seven interchangeable tables are offered; others made to order. Speed range 85 to 285 oscillations per minute. Automatic timing device can be set from 0 to 55 minutes or to run continuously.—*New Brunswick Scientific Co.*, 10 *Hiram St., New Brunswick, N. J.*



For more information circle 244 on inquiry card.

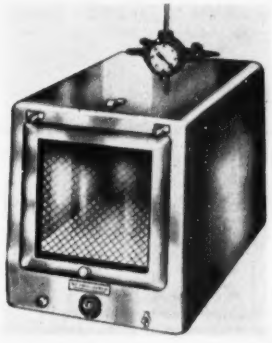
Vacuum Pump

New "ASCO" diffusion pump, when used in conjunction with mechanical vacuum pumps, will reach an ultimate vacuum of 5×10^{-6} mm Hg while operating with a forepressure as great as 5 mm Hg. All vacuum connections are slip-fit rubber tubing. Operation is from standard 110 v.ac. —*Will Corp., P. O. Box* 1050, *Rochester* 3, *N. Y.*

For more information circle 245 on inquiry card.

Vacuum Oven

New type of vacuum oven features safety protection, complete visibility, adjustable dial type thermostat on front panel, door which swings up and out of way, radiant wall heat

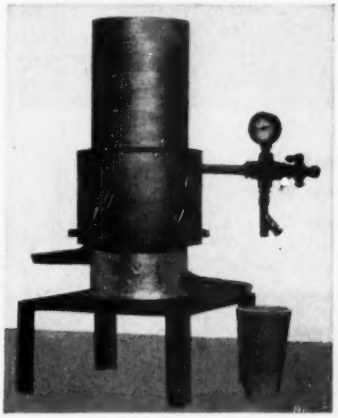


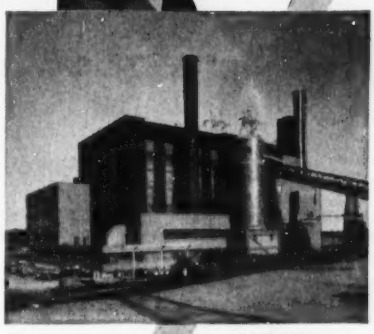
which leaves inner chamber open for greater working capacity.—*The Forma-Heater Co.*, 804 *Warren St., Marietta, Ohio.*

For more information circle 246 on inquiry card.

Cupola Furnace

New low-cost 3-inch cupola furnace is designed for melting ferrous and non-ferrous metals and reducing ores on a laboratory scale for classroom demonstrations as well as for staff and graduate research projects; operates on coke and compressed air;





Schiller Station
Portsmouth, N. H.
Public Service Company
of New Hampshire

"We've found that 'soaping' Swagelok Tube Fittings is just a waste of time . . ."

The power plant pictured above is equipped with Swagelok Tube Fittings installed by Midwest Piping & Supply Company, Inc.

Midwest Superintendent Moran says, "We always 'soap' each joint after original installation. Testing Swagelok Fittings revealed no leaks whatever. We've found that 'soaping' Swagelok Tube Fittings is just a waste of time . . ."

Here's further impressive proof that Swagelok Fittings are leakproof . . . on Ultra-High Vacuum applications, Swagelok Fittings commonly are used in the range of 10^{-7} millimeters of mercury.

Swagelok catalog on request. Address Department 16

Swagelok®

TUBE FITTINGS AVAILABLE IN:
BRASS, ALUMINUM, STEEL, STAINLESS STEEL, MONEL

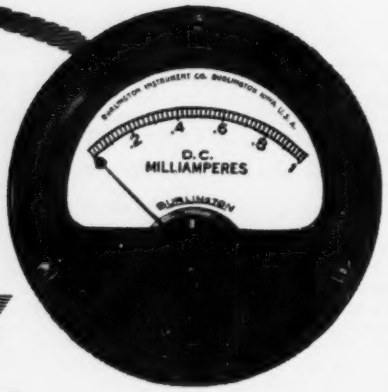
CRAWFORD FITTING CO.

884 East 140th Street Cleveland 10, Ohio
Teletype CV-785

For more information circle 49 on inquiry card.

Burlington

HERMETICALLY AC-SEALED-DC INSTRUMENT



- Copper—cadmium—dichromate finished case.
- Black satin anodized aluminum bezel.
- Excellent shielding due to case material and construction.
- Double strength clear glass.
- Glass to metal seal under controlled humidity and temperature conditions.
- D'Arsonval permanent magnet type movement for DC applications.
- Magnetically damped, moving iron vane type movement for AC applications.

RUGGED CONSTRUCTION FOR SUPERIOR PERFORMANCE

- Available in 1½" square, 2½" and 3½" round case types.
- Guaranteed for one year against defective workmanship and materials.

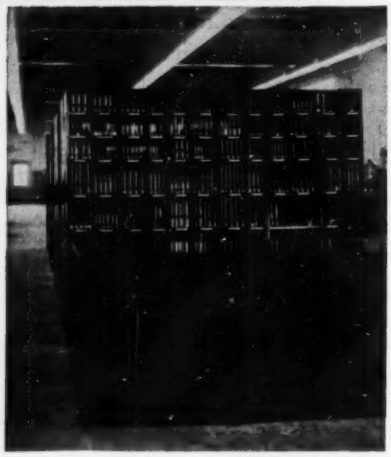
Burlington "Hermetically Sealed" Instruments are designed to conform to JAN and MIL specs.

B BURLINGTON INSTRUMENT COMPANY
DEPT. H-73, BURLINGTON, IOWA

For more information circle 50 on inquiry card.

AVAILABLE NOW! from Stock

TRINITY THERMOWELLS



—in a wide variety of designs, sizes and materials.

We will be glad to place your name on the list to receive copies of the monthly Trinity Thermowell Stock List.

Request your copy now.

2106

TRINITY EQUIPMENT CORPORATION
494 Westfield Ave., East Roselle Park, New Jersey
THERMOWELLS and other Specialties for the Process Industries

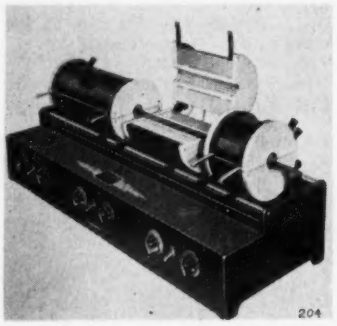
For more information circle 51 on inquiry card.

has a production capacity of 60 pounds of cast iron per hour.—*Foundry Rubber Inc.*, 6100 *River Road, Washington* 16, *D. C.*

For more information circle 247 on inquiry card.

Combustion-tube Furnace

New model of maker's Organic Combustion Tube Furnace has three separate furnaces mounted on rails, enabling operator to use furnace as



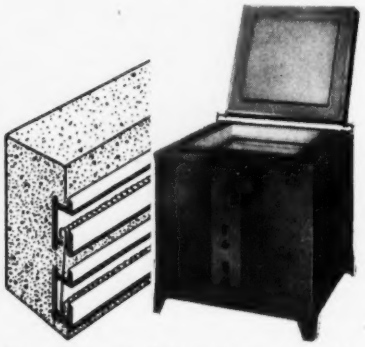
204

one unit or three units. Each section has individual temperature control with new 36-step tap changing transformer.—*Hevi Duty Electric Co., Milwaukee* 1, *Wis.*

For more information circle 248 on inquiry card.

Electric Furnaces

New line of 37 "Dyna-Kiln Electric Furnaces," heated by new "Dyna-Glow Elements" resting in "Dyna-

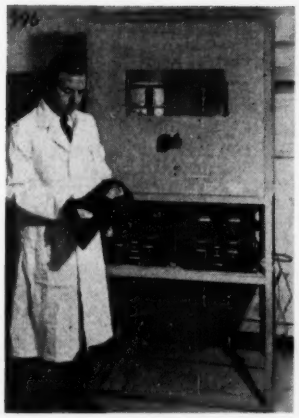


Glow Element Holders," are available in 2050 F. and 2300 F. ranges; embody 18 improvements but without price increases.—*The L & L Mfg. Co., Chester* 50, *Penna.*

For more information circle 249 on inquiry card.

Crystal-growing Furnace

New crystal-growing furnace is said to be the first complete packaged equipment for controlled growth of organic scintillation crystals. Furnaces are housed in a thermostatically controlled ambient-temperature reservoir. Crystals are grown from melt of any desired luminescent material of melting point between 100 and 500 C. by Stockbarger method. Molten phosphor material is transported through a sharp temperature gradient at rate of one inch in thirty hours. Seed crystal formation and crystal-



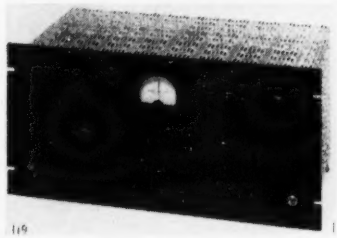
liquid interface propagation may be directly observed (internal illumination provided).—*Wakefield Industries, Inc.*, 5108 *W. Grove St., Skokie, Illinois.*

For more information circle **250** on inquiry card.

FOR THE TESTING DEPARTMENT

Resistor Tester

New "Electronic Resistance Analyzer," for selection and measurement of resistors, is available in either rack or bench model; is designed for 115

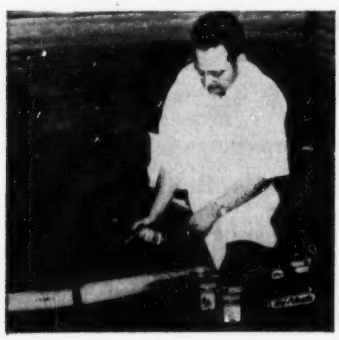


v.ac. operation. Range and accuracy: 1,000 to 10,000 ohms, to 0.5 percent; 10,000 ohms to 11 megohms, to 0.15 percent; 11 to 111 megohms to 1 percent.—*Electronics Div., The Kulyan Corp.*, 1200 *N. Broad St., Philadelphia* 21, *Penna.*

For more information circle **251** on inquiry card.

Flaw-locator Kit

New "Dy-Chek" kit permits on-the-spot inspection for metal soundness to be made on any metal at any location; can easily be carried in one



WITH FOUR-WINDOW

X-RAY TUBE FLEXIBILITY

★ The effective line focus of the NORELCO basic X-ray Diffraction Unit is 0.06 x 10 mm. This unique line focus X-ray tube provides an effective slit source of intense radiation affording maximum resolution in shorter exposure times for diffractometry.

Radiation output from four windows provides opportunity to extend the utility of the basic X-ray Diffraction Unit —to operate two goniometers from the two slit sources and a choice of cameras from two simultaneously available spot sources. This single feature increases operational speed and overall efficiency over other designs with fewer X-ray windows. An *exclusive* NORELCO feature.

A Norelco PRODUCT NORTH AMERICAN PHILIPS COMPANY, INC.

Serving Science and Industry

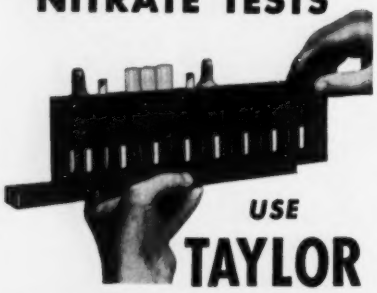
Dept. IM-7 • 750 South Fulton Ave., Mount Vernon, N.Y.

In Canada: Rogers Majestic Electronics Ltd., 11-19 Brentcliffe Road, Leaside, Toronto 17, Ontario

For more information circle **52** on inquiry card.

How to make

ACCURATE pH, CHLORINE, PHOSPHATE, NITRATE TESTS

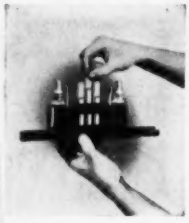


USE TAYLOR COMPARATORS

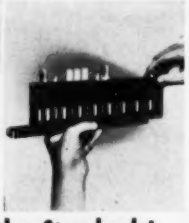
You can make many determinations in seconds . . . longest take only two minutes. Taylor Sets are lightweight, easy to carry for on-the-spot tests, or you can use them in the lab. Each set complete with accessories and reagents.

***Easy as* A • B • C**

A. Fill three test tubes with sample to be tested and place them in the base.



B. Add reagent to middle tube only.



C. Place color slide on base, move across until colors match, and . . . THERE'S THE VALUE!

Guaranteed Color Standards!

Sealed-in-plastic color standards carry an unconditional guarantee against fading that gives you complete freedom from mechanical inaccuracy in making determinations. No single standards to handle. Each slide contains a complete set of standards for any one determination.

SEE YOUR DEALER . . . for equipment. Write direct for FREE HANDBOOK on pH and Chlorine control in 34 basic industries. Also illustrates and describes all Taylor Sets.

W. A. TAYLOR AND CO.
416 RODGERS FORGE RD • BALTIMORE 4, MD

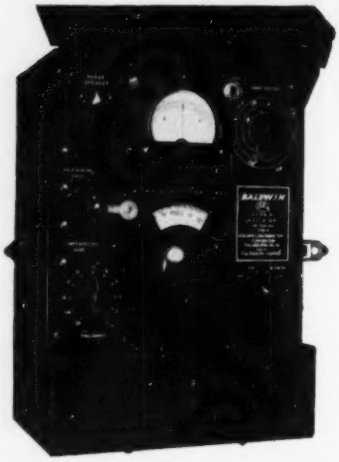
For more information circle **53** on inquiry card.

hand. "Dy-Chek" materials are applied in field as in plant. Pre-cleaning is accomplished with "Dy-Chek Dye Remover." Brilliant red "Dy-Chek Dye Penetrant" is then brushed onto surface; is allowed to dwell long enough to enter defects; excess penetrant is removed. Two pressurized sprayers of "Developer" have been provided in each kit. Cracks show as brilliant red lines; red dots indicate porosity. Depth of defects is indicated by richness and speed of bleed-back.—*Turco Products, Inc., 6135 South Central Ave., Los Angeles 1, Calif.*

For more information circle **252** on inquiry card.

Strain Indicator

New "Model M" portable SR-4 strain indicator is designed for operation with either batteries or a-c. power pack; is functionally identical

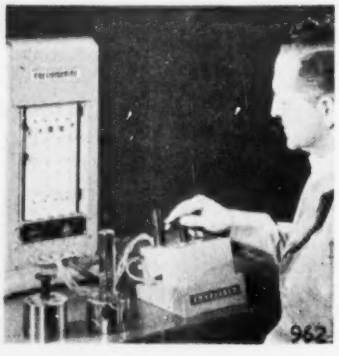


to "Model L." Changes: provision on null indicator for checking a-c. line voltage and addition of a fuse to protect circuit when using power pack. —*Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.*

For more information circle **253** on inquiry card.

Piston Inspector-classifier

New type piston gage provides simultaneous gaging of piston skirt diameter at two places, of taper from top to bottom, and of cam grind on skirt at three points; also indicates in which one of eight diameter classifications each piston belongs. Equip-



ment comprises a chrome-plated ring containing a number of air jets and two "Plunjets" connected to a five-column "Precisionaire."—*The Sheffield Corp., Dayton 1, Ohio.*

For more information circle **254** on inquiry card.

Industrial Fluoroscope

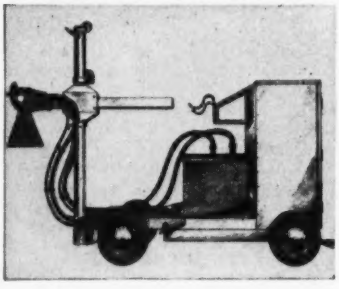
New "Scopemaster" industrial fluoroscope is designed for mass inspection of light alloy castings; also for inspection of plastic products. A sin-

gle external control handle permits moving parts to be inspected in any lengthwise or crosswise direction while in the x-ray beam. Distances between receiving screen and product part may also be adjusted by operator during inspection. Internal cavities 0.040 in. in size, or approx. 6 percent of metal thickness in an aluminum alloy casting can be detected.—*X-ray Dept., General Electric Co., 4855 Electric Ave., Milwaukee 4, Wis.*

For more information circle **255** on inquiry card.

Mobile X-ray Unit

New "Model 413" 250-kv mobile x-ray unit for radiographing unwieldy objects embodies improvements principally in flexibility and ease of han-



dling. Operator has been given additional protection so that he can stand inside cab. Minimum tube-head-to-floor distance is 36 in. and maximum 108 in. Throughout this 72-in. vertical travel, tubehead has a horizontal travel of 48 in. Vertical column can be rotated 360 deg.—*Section X, Westinghouse Electric Corporation, 2519 Wilkens Ave., Baltimore 3, Md.*

For more information circle **256** on inquiry card.

Industrial Radiography Units

New industrial line of radiography equipment differs radically from medical units modified for industry: new units were specifically designed. (1) "MG 150" 150-kvP constant-potential generator (Fig. 1) is housed in a

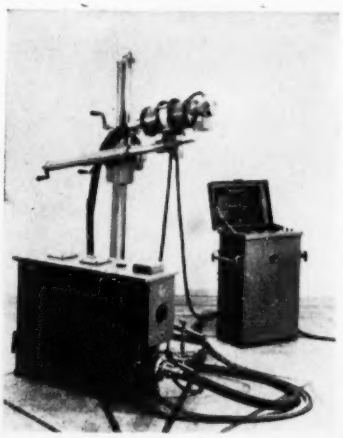


Fig. 1

single tank which is easily moved. High tension cables may be as long as 75 feet for pipe welds and ship construction. Control cabinet houses all controls and regulators. Feature is pre-indication of high voltage required as well as measurement of true tube voltage during operation, regardless of tube current. (2) "MG 300" 300-kvP constant-potential dual gen-

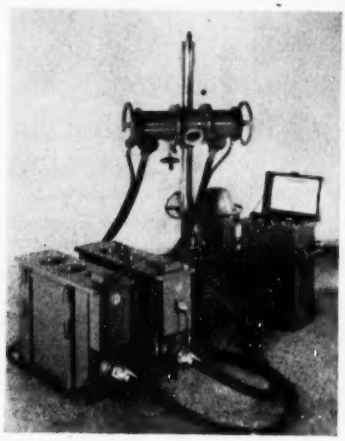


Fig. 2

erator for heavy-duty industrial inspection (Fig. 2) has same features as 150-kv unit. Tubestand device is a heavy-duty hydraulic lift truck equipped with casters.—*Non-Destructive Testing Dep't, X-ray Div., North American Philips Co., Inc.*, 750 *S. Fulton Ave., Mount Vernon, N. Y.*

For more information circle **257** on inquiry card.

FOR INSTRUMENT SHOP

Radial-play Gage

New pivotal-arm type "Radial Internal Clearance Measuring Instrument" may be used to measure radial play in ball bearings on a production basis as well as inspect incoming shipments or set up control over radial play before bearings are assembled with their components. One standard model for bearings with 18 to 90 mm. OD; another for 90 to 180 mm. OD. Features: two adjustable air-operated pivotal load-bearing arms that alternately exert upward and downward

The new Bendix-Pacific TOR-6 Oscillator gives improved performance with resistance type strain gages and variable resistance type temperature pickups. The unit operates with unusual stability under extreme conditions of environment.

Unbalance of the resistance bridge provides a voltage which is used to change the frequency of the oscillator. The magnitude and direction of the frequency change is proportional to the magnitude and phase of the bridge output.

SPECIFICATIONS

Bridge Impedance: 120 ohm*
Sensitivity: ±7.5% change of f_o for 0.125% change in resistance in each of four active arms*. (This is RDB specified subcarrier bandwidth)
Frequency Response: Flat within ±2.0% from DC to 10% of bandwidth.
Linearity: Within 1.0% of best straight line.
Stability: Drift less than 0.5% of bandwidth (0.07% of f_o) for 8 hours at 25° C. after 15 minute warmup.
Temperature Effect: f_o changes less than 0.08% of bandwidth per degree centigrade.
Vibration Effect: 1.0% maximum noise at 10 g, 20 to 1000 cps.
Supply Voltage Effect:
Plate Supply: Drift does not exceed 1.0% of bandwidth for ±10% change of plate supply voltage.
Heater Supply: Drift does not exceed 1.0% of bandwidth for ±10% change of heater voltage.
Output: 1.5 volts rms into 100 kilohms resistive load. Generator impedance 750 kilohms.
Harmonic Distortion: 2.0% maximum.
Power Requirements:
0.015 A at 108 volts DC
0.800 A at 6.0 volts DC or rms AC.
Bands of Operation: Standard RDB bands 1.7 through 14.5 kc*.
Size: 4.5" long x 1.45" wide x 1.35" high; occupies 2 sections of Bendix TJS Component Mounting Assembly.
Weight: 0.4 pounds.

*Available for other bridge impedances, sensitivities, and bands of operation on special order. For temperature measurement, ±0.5% change of resistance in one arm produces ±7.5% change of f_o.

Write for complete information.

Pacific Division
Bendix Aviation Corporation
NORTH HOLLYWOOD, CALIF.
Bendix

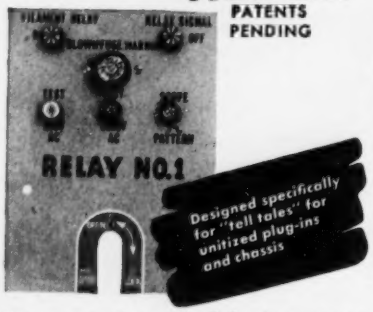
EAST COAST OFFICE: 475 FIFTH AVE., NEW YORK 17, N.Y.
EXPORT DIVISION: BENDIX INTERNATIONAL, 72 FIFTH AVE., NEW YORK 11 N.Y.

For more information circle **54** on inquiry card.

From Alden's Line of Ready-made Components for Unitized Plug-in Unit Construction:

Miniature Sensing and Indicating Components by ALDEN

PATENTS PENDING



The new trend to unitized plug-in construction calls for tiny sensing and monitoring devices to act as "telltales" when trouble occurs. Device must be rugged, yet take a minimum of panel space. Here are latest in Alden Series to meet this problem.

ALDEN "PAN-i-LITE"

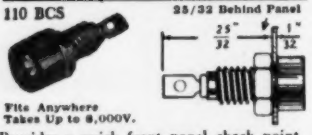
86L
Mounts in .348" hole
Quickly replace bulb from front of panel
Bulb and Lens are 1 pc. instantly replaceable with unbreakable spares.

You can use this new tiny Alden Pan-i-Lite indicator where never before possible. Easily serviced one-piece lens-bulb replaceable from front of panel. Mounts simply by pushing into .348" hole. Gives beautiful indication; glows like a red hot poker. Tiny spares can always be kept ready in kit or taped in recess of equipment. Available in 6V, 12V and 28V, various colors.

ALDEN "FUSELITE"

Spot trouble instantly. Neon indicator light in lens glows when fuse blows. One-piece molded lens-and-indicator-lite unscrews from front of panel. Ideal for monitoring power to each unitized circuit. Available for 28V, 110V and 250V.

ALDEN TEST POINT JACK



Provides a quick front panel check point for any circuit voltages in your equipment. This tiny Jack fits .257" hole and takes only 25/32" behind panel. Beryllium copper contact withstands hundreds of insertions. Phenolic or nylon insulation, many colors.

SEND FOR FREE SAMPLES

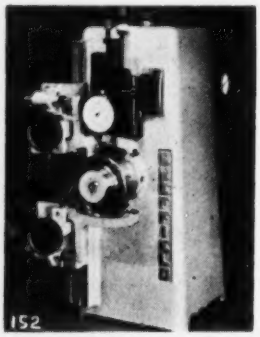
— also request free "Alden Handbook" 226 pages of techniques and components for Unitized Plug-in Unit Construction.

NACAL ALDEN PRODUCTS CO.

137 N. Main St., Brockton 64, Mass.

For more information circle 55 on inquiry card.

NEW INSTRUMENTS



pressure on bearing; measures successive movements of outer ring to determine amount of radial play of bearing in that position; automatic shakedown of balls into bottom of groove; three-station foot-pedal control of load bearing arms.—*Sheffield Corp., Dayton 1, Ohio.*

For more information circle 258 on inquiry card.

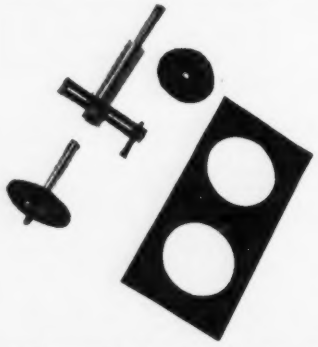
Gage-block Accessory Set

New "Standard Gage Block Accessory Set No. 11" consists of four gage block clamps (1.5, 4, 6.5 and 12 in.), plus a pair of 0.250-in. straight jaws, a pair of 0.250-in. half round jaws, center point, scriber and base block. These combine with blocks into a variety of snap, ring and height gages, calipers and scribers for every dimension under 12 in.—*Webber Gage Co., 12900 Triskett Road, Cleveland, Ohio.*

For more information circle 259 on inquiry card.

Fly Cutter

New "No. 800" fly cutter is an improved tool for cutting large circular holes (1.25 in. to 5.25 in. diam.) in panels of plastic, wood or metal up

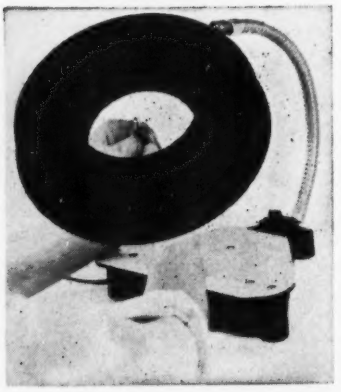


to 0.5 in. thick. It is free of cutter gouging and cutting-blade interference. "No. 802" extension arm permits cutting holes up to 9.25 in. diam.—*Mico Instrument Co., 86 North Trowbridge St., Cambridge, Mass.*

For more information circle 260 on inquiry card.

Illuminated Magnifier

New "Stratolite" non-glare inspection lamp has a magnifying lens as an integral part. It comprises an 8-in. Circline fluorescent lamp recessed in a black shield, plano-convex mag-

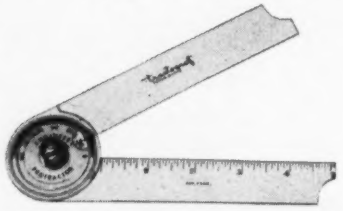


nifying lens, black aluminum base weighted to form a stable lamp in any position, cream-colored base platform, and completely flexible arm.—*Strat-O-Seal Mfg. Co., 3039 W. Fullerton Ave., Chicago 47, Ill.*

For more information circle 261 on inquiry card.

Adjustable Protractor

New "Tractograf" engineer's protractor is said to be a miniature drafting machine in itself. Angles from zero to 180 deg. can be drawn instant-

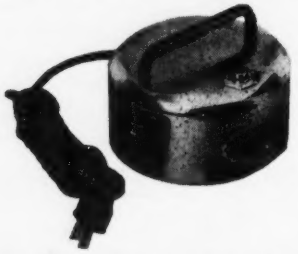


ly without turning, sliding, or moving protractor out of position at any time. A magnifier is built-in over registration mark. Often-needed mathematical formulae are printed on reverse side.—*Way-Mac Mfg. Co., 8112 Melrose Ave., Los Angeles 46, Calif.*

For more information circle 262 on inquiry card.

Demagnetizer

New "Jiffy-Rase" demagnetizes magnetized metals and tools, obviates tedious job of brushing, wiping and



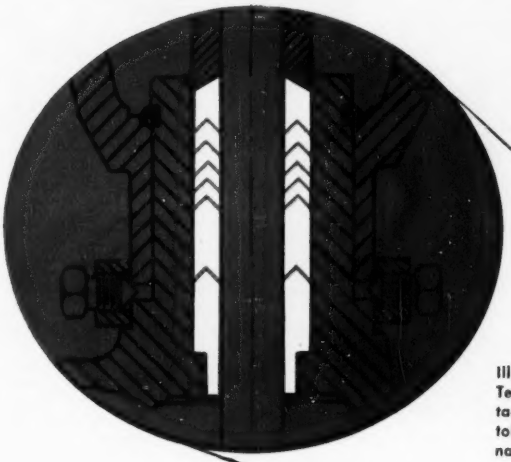
picking them clean before work can continue. It plays into any 110 v.ac. socket.—*Dept. 50, Rason Mfg Co., 3050 W. 21st St., Brooklyn 24, N. Y.*

For more information circle 263 on inquiry card.

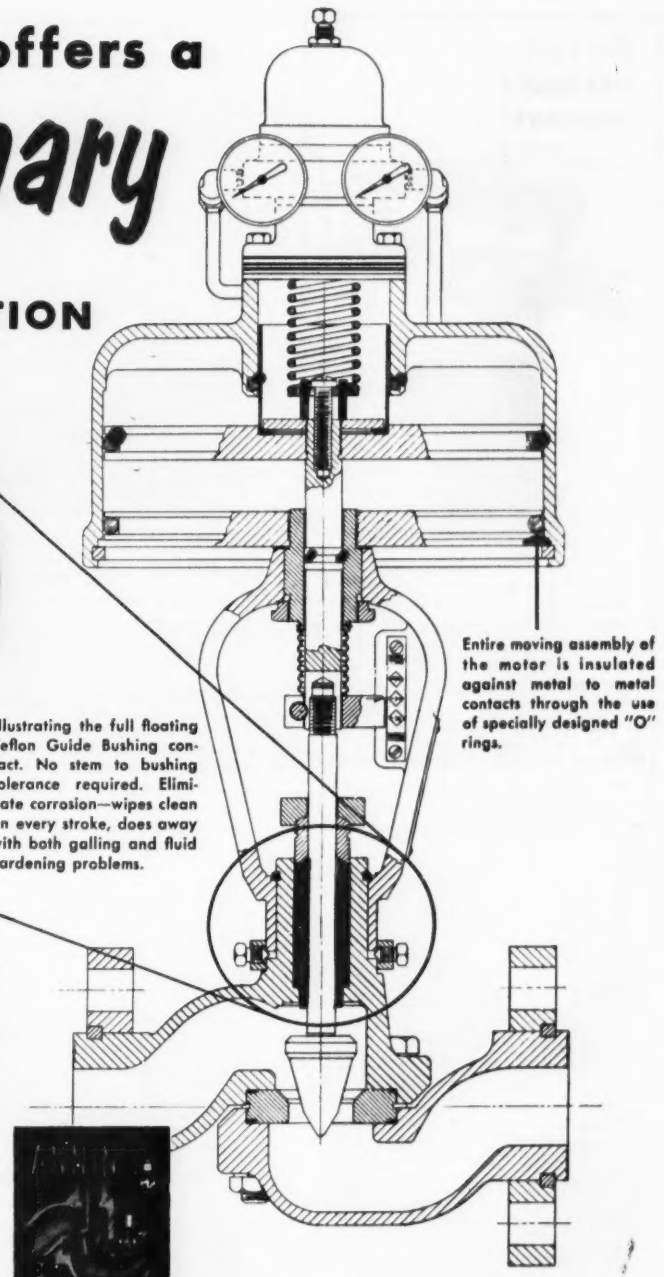
Jet-blade Air Gage

New air gage measures dimensions over rolls of serrations in root section of jet engine turbine blades. Fixture is made with tungsten carbide

Now ANNIN offers a *Revolutionary* PRINCIPLE IN VALVE CONSTRUCTION



Illustrating the full floating Teflon Guide Bushing contact. No stem to bushing tolerance required. Eliminate corrosion—wipes clean on every stroke, does away with both galling and fluid hardening problems.



Entire moving assembly of the motor is insulated against metal to metal contacts through the use of specially designed "O" rings.

By incorporating a Teflon Guide Bushing,—Annin design provides mechanical perfection in control valve operation. How? Because now Annin valve offers full floating operation free from any metal to metal contact in moving parts. The valve stem floats in contact with Teflon,—the Domotor portion of the valve floats on Hycar "O" rings. Teflon eliminates valve stem galling, and all difficulties which develop when soft, corrosion resisting alloys are in contact as bearings.

Teflon is self-lubricating and requires no external lubrication. It won't stick so the customary tolerance between guide bushing and valve stem is eliminated. With the new type guide bushing used by Annin, an interference fit is provided and solidly retains the valve stem and plug assembly. The stem is wiped clean on every stroke preventing scale or dirt from scoring or any tendency toward fluid hardening problems. Valves now in service may be changed over to the new guide material.

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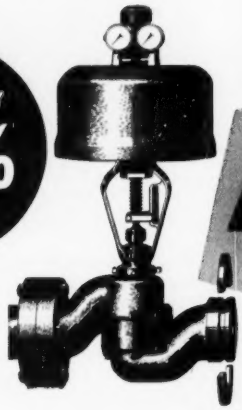
CUT INVENTORY 50% WITH



ANNIN *Control* VALVES

THE ANNIN COMPANY 3500 Union Pacific Avenue
Los Angeles 23, California

For more information circle 56 on inquiry card.

for fast . . .
accurate . . .
engraving . . .

Pictured above is the PREIS-PANTO Model 2D-4 Precision Engraving Machine for use on large metal or plastic panels, signs and name plates; steel stamps and dies or any product requiring precision engraving.

PANTO — Write for 2D-4 Bulletin and prices

H. P. PREIS Engraving Machine Co.
661 U. S. Highway 22 Hillside, N. J.

For more information circle **57** on inquiry card.

THE ERA TYPE 41103 HIGH-GAIN PLUG-IN AMPLIFIER

Maximum voltage gain of 9,000—Case dimensions only 3" x 2¼" x 1⅛"—Frequency response substantially flat from 2 to 1,000 cps.—Reduces power supply surges by a factor of 5 and ripple by a factor of 25 in output—Particularly well adapted to applications involving low-level low-frequency inputs. Important application is its use in wide-range integrating circuits in which integration is achieved by a stabilizing negative-feedback circuit.

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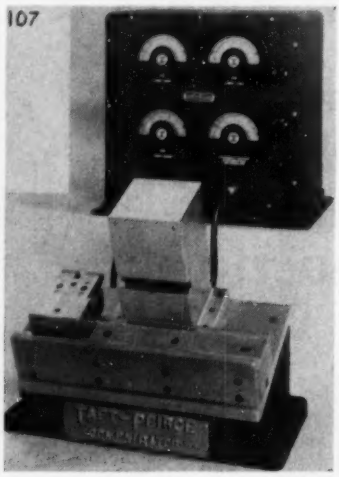
For more information circle **58** on inquiry card.

NEW INSTRUMENTS

107



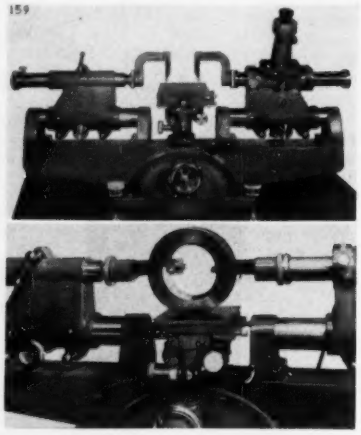
contacts, mounted on parallel reeds so that they are free to move both vertically and horizontally to permit them to position themselves correctly. Three air indicators, with dial graduations of 0.0001 in., show dimensions of serrated sections. In addition, maker's new "Computing Indicator" computes automatically the difference between the amounts that each of two dimensions varies from its mean value.—*The Taft-Peirce Mfg. Co., Woonsocket, R. I.*

For more information circle **264** on inquiry card.

Measuring Machine

New "Microptic Measuring Machine" (horizontal type) uses a built-in 4-in. glass scale for measuring lengths or diameters of gages and

159

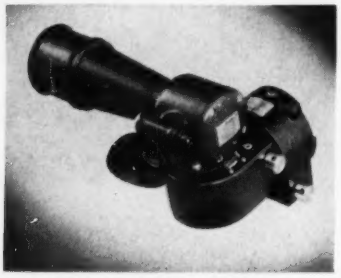


parts to 0.00005-in. direct-reading and 0.00001-in. by convenient estimation. With simple 4-in. standards, it can be extended to a maximum capacity of 14 in. external and 10 in. internal measurement. Work table is fully adjustable, including tilt and rotation, for quick alignment of workpiece. As no gage blocks or other length standards are required with each measurement, machine is self-contained; built-in scale operates without wear.—*Engis Equipment Co., 431 S. Dearborn St., Chicago 5, Ill.*

For more information circle **265** on inquiry card.

Radar Boresight Telescope

New Radar Boresight Telescope, for calibration and long-term checking of permanent and portable radar an-



tenna installations, has 10x elbow 'scope (15x models also available). Mount has locking type altitude-azimuth scales of plus and minus 10 deg. with fine vernier adjustment.—*Aremac Associates, 329 W. Washington St., Pasadena, Calif.*

For more information circle **266** on inquiry card.

NUCLEONICS

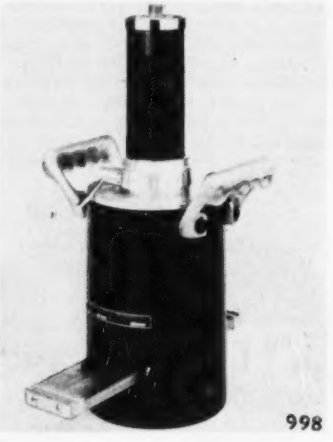
Punched Cards for Nuclides

New sets of punched cards classifying properties of the almost 1200 known nuclides employs McBee "Keysort" system which allows rapid manual selection of nuclides by nine major characteristics such as atomic number, mass number, chemical symbol, stability or radioactivity, availability, type of radiation, half-life, and energy of radiations.—*Radioactive Products, Inc., 443 W. Congress, Detroit 26, Mich.*

For more information circle **267** on inquiry card.

Lead Shield

New "Model LH-3" lead shield, designed especially for scintillation counting of planchets, has 1.5 in. of lead surrounding counter and sample;



998

takes planchets up to 2-in. diameter and 0.25 in. deep. Two-position slide moves easily on steel balls; one sample may be counted while other is being replaced.—*Nuclear Research and Development Co., 6425 Etzel Ave., St. Louis, Mo.*

For more information circle **268** on inquiry card.

EPLAB

Thermopiles

For many years the thermopile has been the accepted instrument for measuring Radiant Heat from Radiant Heaters at the American Gas Association Testing Laboratory in Cleveland, Ohio. Since 1930, when Vandaveer first described his work in this field,* an Eppley thermopile has been used for this purpose in hundreds of tests and the results have been consistent and accurate to within 1 per cent.

This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.

All Eppley Thermopiles are supplied with a certificate of calibration, this calibration being made against a Standard Lamp from the National Bureau of Standards.

If you have a problem involving the measurement of radiant energy we invite you to write us, describing your problem in as much detail as possible. We will be glad to make recommendations and there will be no obligation.

*Vandaveer, *Industrial & Engineering Chemistry*, Vol. 22, page 596, June 1930.

BULLETIN No. 3 ON REQUEST—Address: 2 Sheffield Ave., Newport, R. I.

THE EPPLEY LABORATORY, INC.

SCIENTIFIC INSTRUMENTS

NEWPORT, RHODE ISLAND, U. S. A.

For more information circle 59 on inquiry card.

"Building-block" Counters

New instruments and components for counting particles and photons comprise fifteen "building blocks"

which will do "any type of counting in the nuclear field" and therefore permit low-budget projects to expand at least cost.—*Detectolab Inc.*, 6544 *Sheridan Rd., Chicago* 26, *Ill.*

For more information circle 269 on inquiry card.

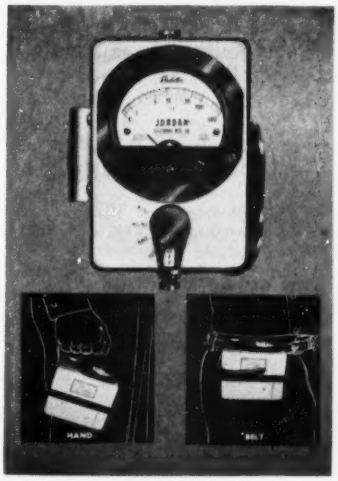
Cosmic-ray Counters

New cosmic ray counters embody the following improvements: (1) Increased area of evacuation tubulation, whence better control of evacuation techniques; (2) sturdier construction at evacuation point, whence longer life; (3) new construction allows more intense heating during evacuation, whence better outgasing of counter walls and longer useful life.—*Dep't* 5, *Radiation Counter Labs, Inc., Nucleonic Park, Skokie, Illinois.*

For more information circle 270 on inquiry card.

Gamma-radiation Detector

New "Radector" portable radiation detection utilizes Neher-White Ionization Chamber which makes it possible for a single instrument to measure from the radiation of common soils to rays over 15,000,000 times as strong. Two dual-range models: "AG-50" measuring from 0.05 mr/hr to 50 mr/hr and 0.05 R/hr to 50 R/hr;



ERA SHAFT MONITOR shaft position indicators detect angular position of a rotating shaft and convert the result to digital representation.

ACCURACIES of 0.09-degree are practical. Measurements may be displayed remotely in digital form or transferred to magnetic tape, punched tape, punched cards or used for control.

For more information on ERA Shaft Monitor Analog-to-Digital Converter, write on your business letterhead to:

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Maximum Electronic Performance in any WEATHER with

LORD TEMPROOF MOUNTINGS ON COLLINS 618S-1 TRANSCEIVER

SENSITIVE electronic equipment for airline transmitting and receiving must give continuously accurate results. For instance, note this "inside" view of the Collins Transceiver, mounted on Lord Temproof Mountings which isolate it from vibration and shock. Lord Temproof Mountings function efficiently throughout operational ranges of temperature from —80° to +250°F. The Collins Transceiver with automatically tuned elements for maximum flexibility and high power output delivers maximum performance in any weather, completely protected from vibration, shock and excessive equipment motion at resonant frequencies by Lord Temproof Mountings.

May we give you further details on this Lord application or help you solve your specific mounting requirement?

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CLEVELAND 15, OHIO Room 811 Hanna Building

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER — Headquarters for VIBRATION CONTROL

For more information circle 61 on inquiry card.

NEW INSTRUMENTS

"Ag-500" measuring from 0.5 mr/hr to 500 mr/hr and from 0.5 R/hr to 500 R/hr. Both are powered by 4.5-v. penlight mercury batteries without need of amplification (no vibrators, rectifiers, voltage regulators, etc.). Performance: 350 hours of continuous use with no change in reading, and, with intermittent use, battery life is one to two years.—*Jordan Electronic Mfg. Co., Inc.*, 119 *E. Union St., Pasadena, Calif.*

For more information circle 271 on inquiry card.

Decimal Scaler

New "Model 2105 Decimal Scaler" has improved design features in r-f. h-v. supply for increased reliability and improved regulation compatible

with requirements for scintillation counting. Wide selection of preset counts provides for convenient automatic operation; wide selection of scaling factors provides for operation of an external register, printing device, or counting-rate computer, especially useful with plotting devices for thyroid gland scintigrams.—*Berkeley Scientific Div., Beckman Instruments, Inc.*, 2200 *Wright Ave., Richmond, Calif.*

For more information circle 272 on inquiry card.

Binary Scaler

New "Model DS1 Binary Scaler" is made up from three "Building Blocks" mounted in one "Silver Fox" cabinet, so that purchaser can use different "blocks" with it for other counting problems without added expense. (1) "Model DS2" binary scaling unit (bottom) has a scaling factor of 64, resolving time less than 2 microseconds. (2) "Model DV1" regulated high-voltage supply (top) provides 500-2000 volts continuously var-

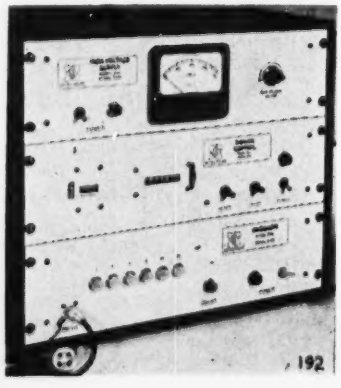
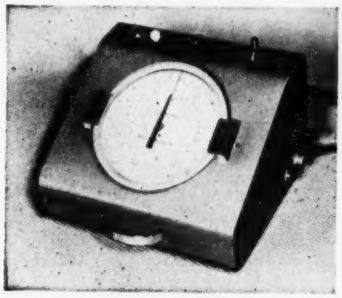


table. (3) "Model DZ5" scaler control panel (middle) will control any number of scaling "blocks" operating in tandem. Timer operates in conjunction with stop-count switch, registers up to 999.99 minutes with accuracy of 0.01 min.—*Detectolab, Inc.*, 6544 *Sheridan Rd., Chicago* 26, *Ill.*

For more information circle **273** on inquiry card.

Count-rate Computer

New "Raychronix Model C-11 Count Rate Computer" simplifies radioactivity counting, operates from output

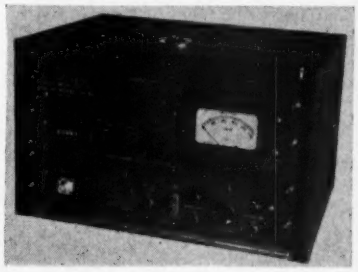


of any scaler, reads directly in average count rate. Important advantage is that it uses no electron tubes. Principle: a synchronous timing motor multiplies a constant (total counts) by reciprocal of time; a "Microswitch" provides delay to nullify backlash.—*Radioactive Products Inc.*, 443 *W. Congress, Detroit* 26, *Mich.*

For more information circle **274** on inquiry card.

General-purpose Scaler

New "Atomlab Model A-63 Automatic Scaler" for detectors operating in Geiger range features manual and



automatic preset count operation ranging from 10 to 100,000 register counts in five steps; automatic predetermined time operation with appropriate relay-type timer; regulated high-voltage supply; 60-cycle check; plug-in binary scailng units; six-digit register.—*Instruments & Equipment, Inc.*, 489 *Fifth Ave., New York* 17, *N. Y.*

For more information circle **275** on inquiry card.

Alpha Monitor

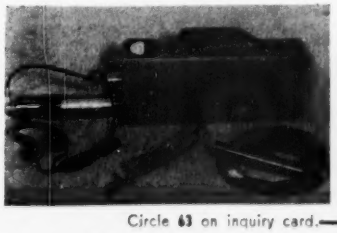
New "Model 2801 Alpha Poppy," for detecting alpha-particle-emitting contamination, meets Oak Ridge Lab

specs Q-1306, has a panel-mounted loudspeaker which produces a "pop" for each alpha particle entering sensitive volume of thin-window single-wire air proportional counter probe. Background counting rate is less than 20 counts per hour.—*Dept. PF-3E, Radiation Counter Laboratories, Inc., Skokie, Ill.*

For more information circle **276** on inquiry card.

Geiger Counter

New "Model 105-D Prospectoscope" can be used for prospecting from low-flying aircraft, from a moving vehicle, or on foot; also for probing drill holes to depths of 50 feet. It is said to be "equipped with the largest gamma-sensitive Geiger tube ever placed in a survey instrument. . . . sensitivity 30 times greater than any other standard Geiger tube." A standard size beta-



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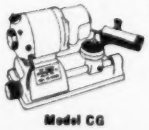
ENGRAVING
MACHINES & Accessories

Designed for fast-easy engraving, etching and electric marking of lettering, design, calibrating and numbering on parts and instruments of any metal, plastic or other material.

Model 2D-4

Model UE-3

You're always safe in buying PREIS-PANTO engraving machines and accessories.



Model CG

Model CG for single lip engraving and routing cutter grinding.

PREIS-PANTO CUTTERS and COLLETS single lip, straight or tapered.

PANTO

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For more information circle **62** on inquiry card.

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SIE

MODEL M-2
OSCILLATOR
is your answer
low distortion...
wide range

The unique SIE oscillator circuit which has no lower limit to its possible frequency of oscillation is responsible for the excellent low frequency performance of the Model M-2 and other SIE oscillators.

SPECIFICATIONS

Range: 1 cps to 120,000 cps.

Calibration: Within 1½% plus 1/10 cycle

Output circuits: 20 volts or 20 millamps and 1 volt at 300 ohms constant impedance

Amplitude stability: Plus or minus ½ db

UNDESIRED VOLTAGES

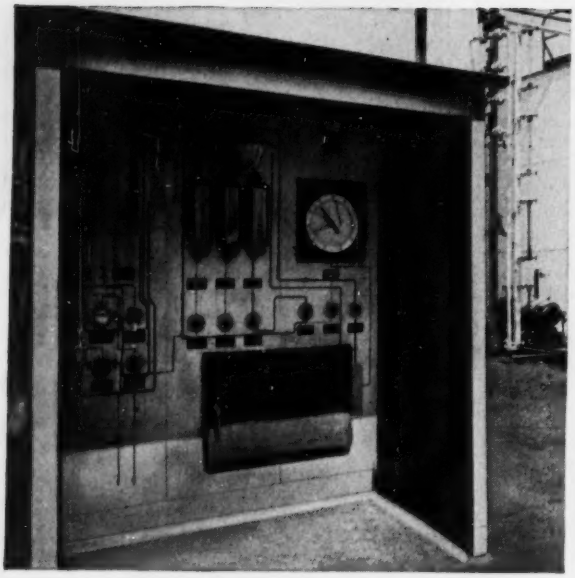
Power Supply Noise: Less than 1/100% of output signal

Power Line Surge: Less than 1/10% of output signal

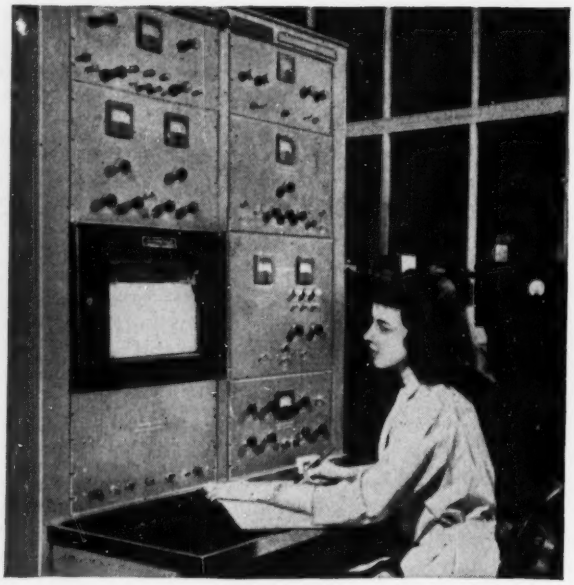
Harmonic Distortion: Less than 2/10% from 20 cps to 15,000 cps. Less than 1% at all other frequencies

Microphonic Noise: Less than 1/100% of output signal

Circle **63** on inquiry card. →



infra-red analysis *tells how much of a selected component exists in gas mixtures. Here, continuous analysis recorded by an* ***ElectroniK*** *potentiometer on a refinery's graphic panel is used for actual process control.*



mass spectrometry *separates materials on the basis of their different molecular weights . . . finds what constituents are present in what quantity. Above is a "package" mass spectrometer in which an* ***ElectroniK*** *instrument records test data.*

gas analyzer, *operating on the thermal conductivity principle, combines an* ***ElectroniK*** *recorder, analysis cell and accessories in a single panel assembly.*

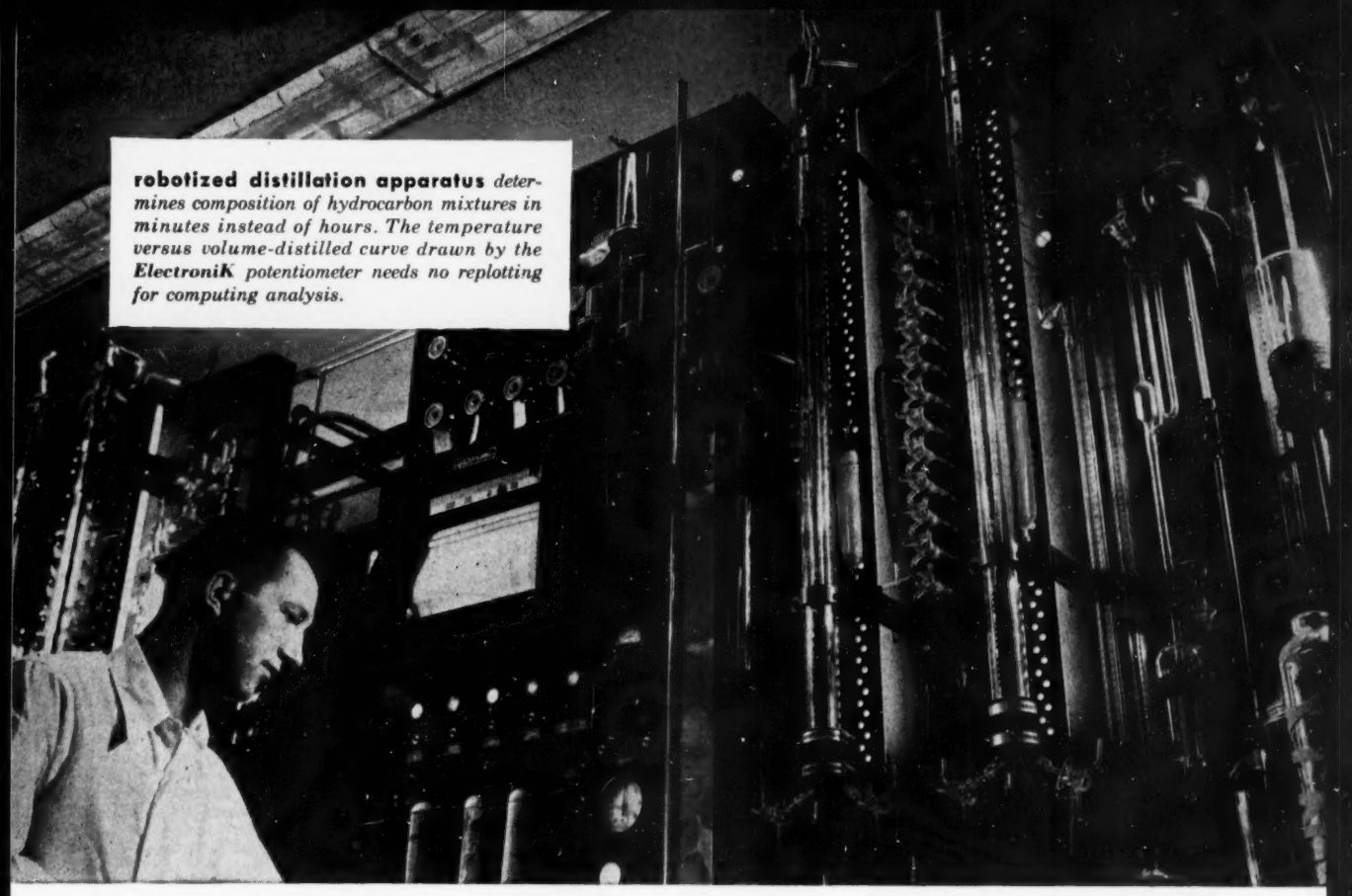
New concepts *utilize*

These are some of the manufacturers who use *ElectroniK* instruments in their analyzers

Products of the companies checked are illustrated on these pages

Applied Research Laboratories	Mine Safety Appliances Co.
Baird Associates	North American Philips Co., Inc.
Bausch and Lomb	Perkin-Elmer Corp.
Beckman Instruments, Inc.	√ Podbielniak, Inc.
Consolidated Engineering Corporation	Precision Scientific Co.
√ Davis Emergency Equipment Co.	E. H. Sargent & Co.
√ General Electric Co.	Tracer Laboratories
Jarell-Ash	√ Applied Physics Corp.

For more information circle 64 on inquiry card. Circle 64 on inquiry card.→



robotized distillation apparatus *determines composition of hydrocarbon mixtures in minutes instead of hours. The temperature versus volume-distilled curve drawn by the* ***ElectroniK*** *potentiometer needs no replotting for computing analysis.*

# of process control

ElectroniK instruments

FROM the analytical laboratory comes a new concept of industrial process control, based directly on the desired chemical or physical characteristics of the product.

Continuous analyzers now make it possible to measure composition of gases and liquids accurately and automatically . . . to record this information . . . even to actuate automatic controls. Instead of temperature, pressure and flow, these new systems deal in terms of refractive index, density, ultraviolet and infrared spectra, radiation intensity and absorption.

An essential component of all these systems is automatic recording. To fill this critical function, leading manufacturers of automatic analyzers choose *ElectroniK* instruments. They choose them for their exceptional accuracy, that exploits fully the inherent precision of the new measuring techniques. They choose them, too, for sensitivity that records every essential change in readily readable detail. And they prefer *ElectroniK* recorders for their simple, rugged design that guarantees dependable service under any industrial conditions.

Your local Honeywell engineering representative will be glad to discuss the role of *ElectroniK* instruments in product-analysis systems . . . or in any conventional process control. Call him today . . . he is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4482 Wayne Ave., Philadelphia 44, Pa.

● **REFERENCE DATA:** Write for Bulletin 15-14, "Instruments Accelerate Research."

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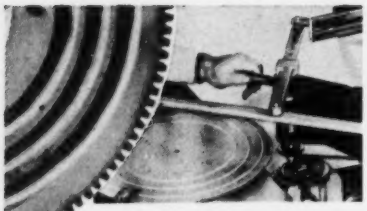
BROWN INSTRUMENTS
First in Controls



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ON METALS AND PLASTICS
Rapidly done by unskilled labor
with NEW HERMES
Engravograph

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Catalog H37 Bench Type Model (weight 200 lbs.) Portable Model IM also available

Production: 6" brass spiral with ¼" x ¼" groove cut from 3 times larger template. Time: 12 units per hour.

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For more information circle 65 on inquiry card.

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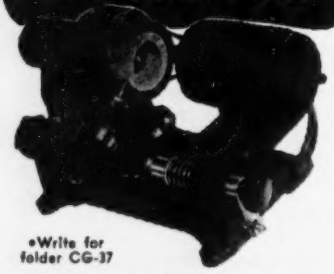
NEW HERMES
CUTTER GRINDER



•Write for folder CG-37

The only belt-driven grinder at low cost.

- Smooth, vibration-free operation.
- Ball bearing grinding spindle.
- Tool head indexed for single lip and 2, 3, 4-sided cutters.

NEW HERMES, Inc.
13-19 University Place, N.Y. 3

For more information circle 66 on inquiry card.

NEW INSTRUMENTS

gamma Geiger probe is interchangeable with 26-in. tube. Five-range indicator gives prospector a broad selection of sensitivities. If airplane engine noise is excessive, earphones provided are used.—*The Radiac Co., Inc., 489 Fifth Ave., New York 17, N. Y.*

For more information circle 277 on inquiry card.

ELECTRICAL INSTRUMENTS

Multi-scale Electrical Indicating Instrument

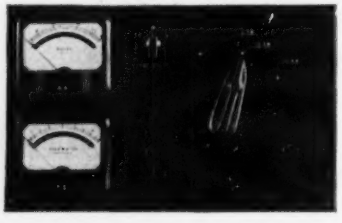
New "Multi-Dialer" multi-scale electrical indicating instrument exposes only one scale at a time and automatically switches appropriate internal or external circuitry associated with

that scale, thereby minimizing human error. Five self-contained ranges in volts, milliampers, microamperes and amperes, or custom-engineered. Panel instrument (mounting to standard JAN 3.5-in. dimensions) or self-contained portable instrument; combination handle and stand permits use on or above bench as well as installed in panels.—*Marion Electrical Instrument Co., Manchester, N. H.*

For more information circle 278 on inquiry card.

Electric-power Analyzer

New "Model 7734 Electrical Power Analyzer" indicates all values from 1 to 20 kw.; has 3 taps, 5-10-20 kw.; measures power in a 3-phase 230-volt 60-cycle circuit. Tap-changing switch changes kw. ranges under load: wattmeter indication is thereby maintained in up-scale position which enhances accuracy in reading. Voltmeter's 3-position switch permits reading voltage balance across any

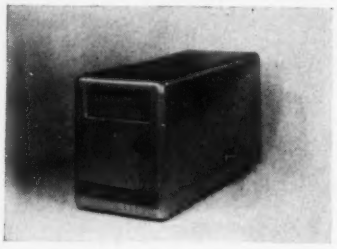


of the 3 pairs of lines. Other models available in combinations or as separate units; a.c. and d.c.; commercial frequencies or all-purpose units 25 to 500 cycles; also as portables.— *Niagaga Electrical Instrument Co., 559 Ellicott St., Buffalo 3, N. Y.*

For more information circle 279 on inquiry card.

Portable Galvanometers

New line of portable galvanometers features high sensitivity made possible by Alnico magnets which give a field strength more than twice that of chrome-steel magnets heretofore used; new tilted scale with hairline



index and spotlight; coil and suspension element removable from magnetic assembly; adjusting knob for setting element on zero permits "rolling back" the hairline to give an effective scale of 280 mm.—*Meter & Instrument Dep't, General Electric Co., West Lynn 3, Mass.*

For more information circle 280 on inquiry card.

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PRESSURE GAGES . . .

Fine pressure gages should also be safe gages.

Gages so built that in case of tube rupture no one will be injured.

The Acragage has always been the safe gage, the gage with the solid front and full area blow-out disc.

Catalog M-50 tells more about the safe ACRAGAGE.

Send for your copy today.

The **ACRAGAGE** *Corporation*
WAMPUS LANE • MILFORD, CONN.

For more information circle 67 on inquiry card.

Ultrasensitive VTVM

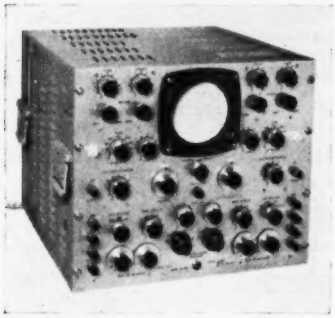
New "Model VM-81" d-c. vacuum-tube voltmeter has eleven ranges from 50 mv. full-scale to 500 volts full-

scale. Accuracy 3 percent of full-scale on all ranges. Input impedance 50 megs on all ranges.—*Scientific Specialties Corp., Snow and Union Sts., Boston* 35, *Mass.*

For more information circle **281** on inquiry card.

Two-channel CRO

New "Model H-25" dual-channel oscilloscope permits two independent signals to be observed simultaneously. Each vertical channel has an independent linear sweep generator continuously variable from 0.02 second-per-inch to 0.2 microsecond-per-inch. A delayed trigger for sweep "B" is available to display and expand any

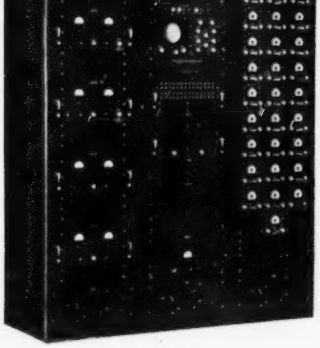


part of sweep "A" with extreme accuracy. Vertical sensitivity, 0.3 v.dc./in., 0.07 v.ac./in. Frequency response, dc. to 10 Mc. Either conductive or capacitive input coupling may be used. —*Electronic Tube Corp.*, 1200 *E. Mermaid Lane, Philadelphia* 18, *Pa.*

For more information circle **282** on inquiry card.

Decommutation System

New "Model 525" low-pass decommutation system for radio-telemetering features maximal accessibility to all units. Over-all accuracy is within



New...

Heiland bridge balance

...and strain indicator

features:

- *One panel operation permits two-position table mounting or standard relay rack mounting.*
- *Individual channel controls for coarse and fine voltage, balance, calibration and attenuation. Coarse and fine voltage controls give continuous voltage adjustment across each channel from 1 to 30 volts.*
- *Convenient and positive locking of all control settings.*
- *One-step precision attenuator.*
- *High sensitivity, two scale transducer output meter permits direct reading of static and slowly changing phenomena. Scales 25 - 0 - 25 microamps and 1 - 0 - 1 for "unit" calibration.*
- *Each channel separately fused. Easy access to fuses, matching calibration, attenuation and dummy resistors.*
- *All component parts carefully selected for maximum operating efficiency under adverse conditions.*
- *Simple, rugged, cast construction. High-gloss, gray enamel finish.*

Model "82-6"

$800.00
Delivery August 1st

The Heiland "82-6" Bridge Balance provides a simple, accurate means of calibrating static and dynamic output from resistive type transducers or strain gages, before feeding these phenomena into a recording oscillograph. Static and slowly changing phenomena may be read directly on the highly sensitive output meter.

SPECIFICATIONS:

Size: 15¾" x 9¾" x 5½" including controls

Weight: 16 lbs. less cables and mounting

Power Input: 0 to 30 volts D.C.

Application: Can be used with any resistive type transducer or strain gage having 120 ohms resistance or greater, and having two, three, or four external arms.

Capacity: Six channels, each with coarse and fine voltage control, balance control, calibration and attenuation switches.

***Write or wire** for further information on the Heiland "82-6" Bridge Balance or catalog of other Heiland equipment . . . oscillograph recorders, galvanometers, associate equipment.*

HEILAND RESEARCH CORPORATION 130 East Fifth Avenue, Denver, Colorado

For more information circle **68** on inquiry card.

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For use wherever precision measurements are required in shop inspection or layout procedures.

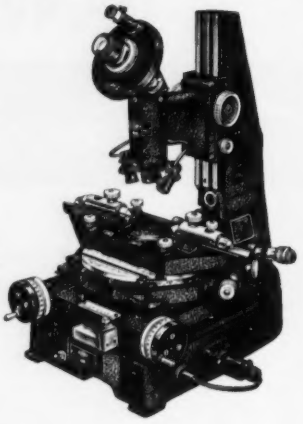
INCH OR METRIC UNITS

Coordinate Measurements
Left to Right.....100 mm or 4 inches
Front to Rear..... 50 mm or 2 inches

Direct Reading to..0.002 mm or 0.0001 inch

Angular Measurements

Stage Range.....	360°
Reading with Vernier.....	1 min.
Protractor Circle Range.....	360°
Reading with Vernier.....	1 min.
Magnification	30X
Microscope Column Tilt	±8°



- **Detects errors in cutting tools.**
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- **Adaptable to flat work, round work, odd shapes.**

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For more information circle **69** on inquiry card.

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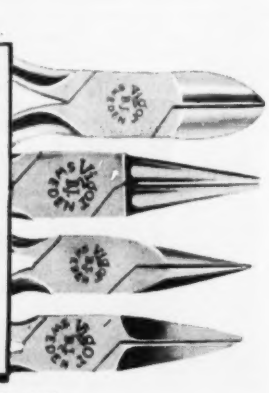


For more information circle **70** on inquiry card.

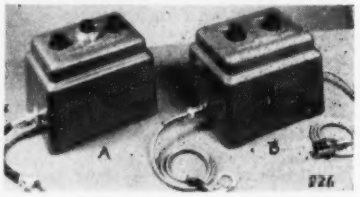
0.5 percent of maximum deviation; output linearity within 0.25 percent. Outputs: (1) pen, (2) remote-indicating device, (3) galvanometer.—*The Ralph M. Parsons Co., 135 W. Dayton St., Pasadena 2, Calif.*

For more information circle **283** on inquiry card.

ELECTRICAL-INSTRUMENT ACCESSORIES

Oscillometric Accessories

New accessories broaden applications of maker's "Model V Oscillometer"; (A) Cell Compensator is designed for use with organic liquids in

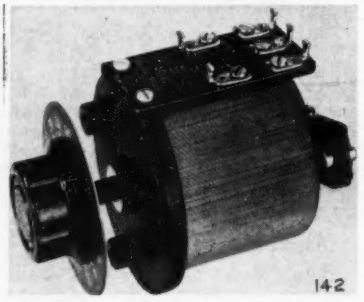


dielectric constant measurement; (B) Oscillometric Recording Adapter provides necessary facilities for operation of common types of recording devices in conjunction with maker's Oscillometer.—*E. H. Sargent & Co., 4647 W. Foster Ave., Chicago 30, Ill.*

For more information circle **284** on inquiry card.

Adjustable Autotransformers

New "Duratrak" silver alloy brush-track surface is now being supplied on all of maker's "V-line Variac" autotransformers. It prevents surface

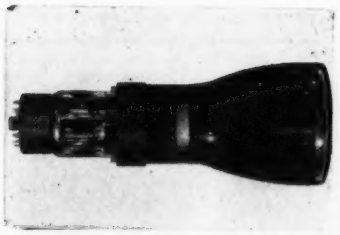


deterioration even when operation at fixed brush settings is carried on continuously. New "Type V-2" 2-ampere "Variac" is also announced, replacing "Type 200-B." It has twice power-handling capacity and has "Duratrak" brush surface.—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

For more information circle **285** on inquiry card.

Five-gun Cathode-ray Tube

New "Type 7X" 7-inch cathode-ray tube displays up to five independent phenomena simultaneously, is built to tighter RTMA specifications, is designed for multi-channel oscilloscopes where a number of transient, random, or h-f. signals must be observed simultaneously with great accuracy. It uses electrostatic focusing and deflection



for each of its five electron guns. Cross talk is eliminated by adequate shielding of individual guns.—*Electronic Tube Corp., 1200 E. Mermaid Lane, Philadelphia 18, Pa.*

For more information circle **286** on inquiry card.

Decade Resistance Box

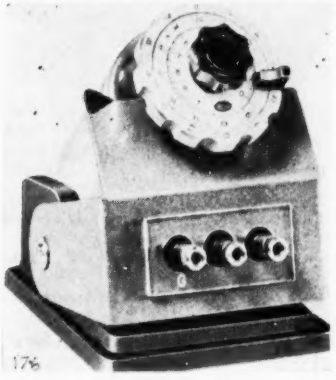
New "Model 7 Decade Resistor" gives preferred RTMA resistor values in 20-percent steps over its entire

range of 10 ohms to 8.2 megohms (10, 12, 15 . . . 820, 1000, 1200 . . . etc.). Accuracy within 2.5 percent. Max. safe ratings shown on multiplier dial. —*Rochester Electronics Co., P. O. Box 227, Penfield, N. Y.*

For more information circle **287** on inquiry card.

Decade Resistance Box

New "Model DB-365 Dekabox" is equivalent of a three-dial precision decade box with range of 0 to 11,990 ohms in 10-ohm steps and accuracy

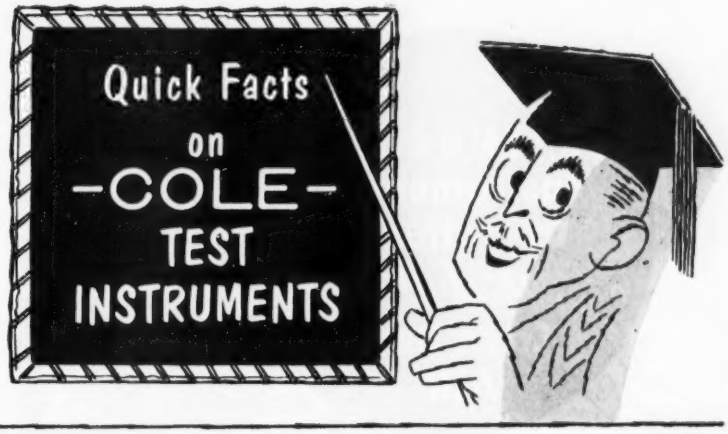


of 0.05 percent plus 0.015 ohm; also available in values of 119, 1190, and 119,000 ohms. "Model DB 265" (not illustrated) has two decades of fixed resistors and one interpolating rheostat for resistances up to 12000 ohms. —*Brown Electro-Measurement Corp., 4635 S.E. Hawthorne Blvd., Portland, 15, Ore.*

For more information circle **288** on inquiry card.

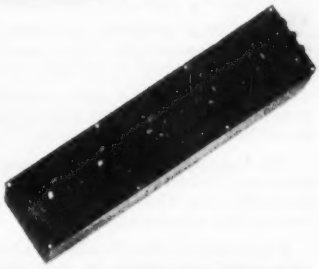
Instrument Amplifier

New "Model B Power Amplifier" is a direct-coupled amplifier with essentially flat response from zero to 20,000 cps.; will deliver 6.25 watts



PRECISION DECADE RESISTANCE BOXES
(Model 1900)

Ranges from 11 to 1,111,100 ohms . . . Each decade assembly is shielded from the adjacent assemblies by partitions cast directly into the metallic case and decades are mounted upon a metallic panel which completes the shielding . . . Extreme accuracy permits their use as laboratory reference standards . . . Individual resistors are used for each step in each decade . . . Wire alloy eliminates errors due to thermal emf generation.



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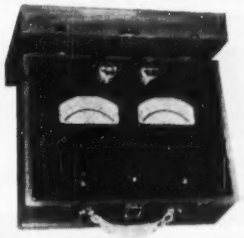
Completely self-contained . . . Reads currents from 0 to 750 amperes, from 0 to 750 volts, and resistance from 0 to 20,000 ohms of direct current . . . Suitable for electric current from fractional to 600 h.p. ratings . . . Only connections required are to load and power circuits . . . Reduces errors in connections. Operator can follow load variations without disconnecting instrument.



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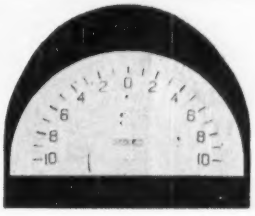
Accurately readable at a distance, and from any angle . . . Saves steps where one operator has multiple jobs to perform . . . Highly valuable in jet propulsion and atomic energy research where instrument must be set up near operation . . . Pointer light eliminates parallax error . . . Available in a wide variety of readings.



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For more information circle **71** on inquiry card.

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For more information circle 72 on inquiry card.

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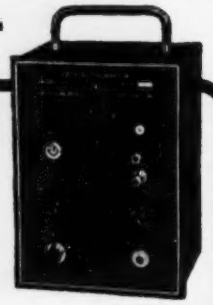

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For The Frequency Calibration Of Equipment In The Range Of

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Frequency Accuracy: ±0.002%

The Model 111 provides a test signal of crystal-controlled frequency and has a self-contained detector of 2 microwatts sensitivity.

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For more information circle 73 on inquiry card.

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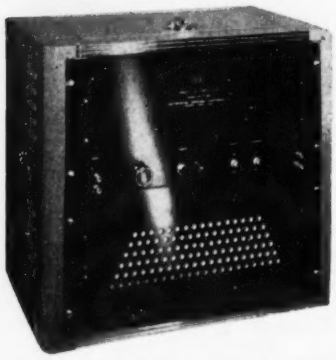


into a 100-ohm load when driven by a 10-volt signal. All types of distortion are held to extremely low levels. It may be used to amplify output of oscillators and signal generators in order to drive servo systems and other power-consuming devices; or to provide power from output of strain-gage bridges and various other pickups.—*Southwestern Industrial Electronics Co., P. O. Box* 13058, *Houston* 19, *Texas.*

For more information circle 289 on inquiry card.

D-c. Amplifier

New "Model 205 Inverter-Amplifier," suitable for CROs and tape recorders, can be used with numerous types of pickups. Voltage gain is

3000; linearity 1 percent; drift 100 microvolts per hour.—*Allegany Instrument Co.,* 1000 *Oldtown Rd., Cumberland, Maryland.*

For more information circle 290 on inquiry card.

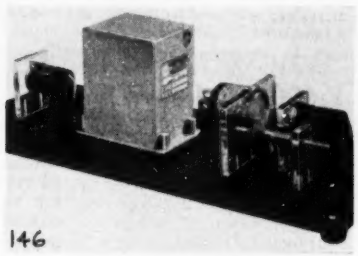
Wide-band Chain Amplifier

New "Model 200B" has extended bandwidth from 1 kc. to 210 Mc. Six 6AK5 tubes in single-stage chain circuit provide 10-db gain uniform within 1.5 db over frequency range. Rise time less than 0.0026 microseconds; input and output impedance 200 ohms. Stabilized power supply minimizes gain fluctuations due to line voltage changes. Unit has a substantially linear phase shift, flat frequency re-

sponse and stabilized gain so that undistorted output voltages up to 2 volts may be obtained.—*Spencer-Kennedy Labs., Inc.*, 186 *Massachusetts Ave., Cambridge* 39, *Mass.*
For more information circle **291** on inquiry card.

Adjustable Magnetic Servo Amplifiers

New adjustable magnetic servo amplifiers permit user to stabilize his



servo loop over wide ranges of performance requirements, load conditions, and gear ratios.—*Magnetic Amplifiers Inc.*, 632 *Tinton Ave., New York* 55, *N. Y.*
For more information circle **292** on inquiry card.

POWER SUPPLIES, ETC.

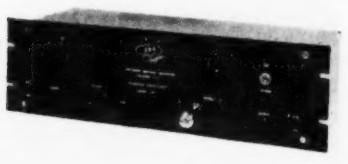
Chopper Stabilizer

New "Model 122 Chopper Stabilizer" provides 0.01 percent stability to output voltage of ordinary power supplies. It was designed for use with

"Super-Regulator Model 121," can also be used with other power supplies. It is identical to "Model 122B" except that it has its own power supply.—*Kalbfell Laboratories*, 1090 *Morena Blvd., San Diego* 10, *Calif.*
For more information circle **293** on inquiry card.

Tubeless Power Supply

New "Model 110" dual tubeless regulated d-c. supply, especially designed for transistor applications, utilizes semiconductor diodes in a bridge rectification circuit, together with saturable reactors to provide for input line regulation. Absence of electronic devices assures extremely long life and negligible warm-up time. Continuously-variable dual outputs supply both collector and emitter voltages in any polarity combination for either point-contact or junction transistors. Output No. 1, rated at 60 ma.



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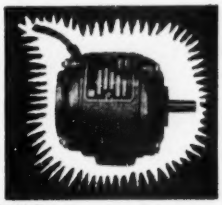

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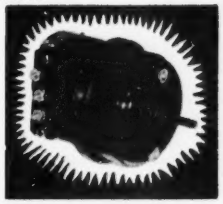

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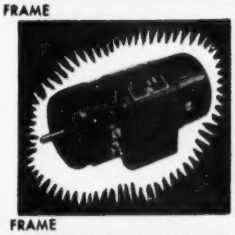

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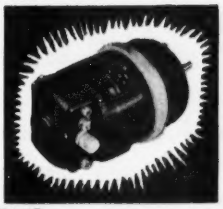

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For more information circle **75** on inquiry card.

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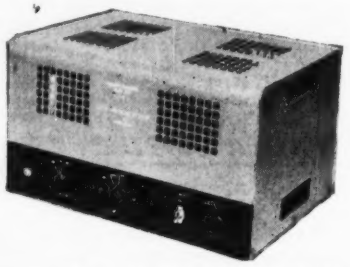
For more information circle 78 on inquiry card.

maximum, can be adjusted for either of three ranges, 0-1, 0-10, or 0-100 volts. No. 2, rated at 60 ma. maximum, yields from 0 to 100 volts d.c. Internal d.c. approx. 0.01 percent and unit is line-regulated for input a-c. variation of 95 to 125 volts. Unit is suitable for laboratory experimentation, production testing, incorporation into equipment, battery simulation for guided missiles, etc.—*Electronic Research Associates, Caldwell, N. J.*

For more information circle 294 on inquiry card.

400-cps. Power Supply

New "Model 400 Frequency Converter" is a portable 400-cps. power supply operating from a standard 60-cps. line, delivering up to 100 volt-amperes, especially suitable for use in development of low-power aircraft equipment. Output voltage is variable

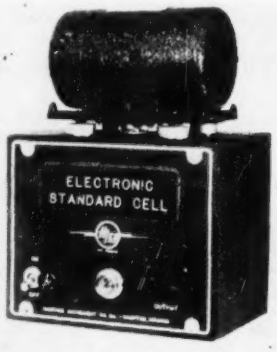


from 105 to 130 volts with regulation better than 1 percent. Frequency is adjustable from 380 to 420 cps with less than 1 cps. drift.—*Avion Instrument Corp., State Highway* 17, *Paramus, N. J.*

For more information circle 295 on inquiry card.

Standard-voltage Power Supply for Aircraft Use

New "Electronic Standard Cell" furnishes a stable power supply from a 28-volt d-c. input. When used intermittently, it has less than 0.15 percent change in output; when used continuously, less than 0.1 percent. A-c. ripple is less than 1 mv. Output range: 0



to 100 volts and 0 to 30 ma. Output voltage is set at factory. New unit can be used as either a reference voltage in bridge circuits or for supplying current continuously as a power supply. Weight, 8 lbs.—*Hastings Instrument Co., Inc., Hampton, Virginia.*

For more information circle 296 on inquiry card.

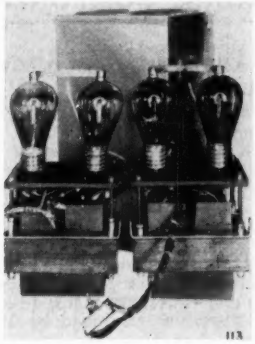
Regulated Power Supply

New "Model 400 Voltage Regulated Power Supply" has B supply continuously variable from 0 to 400 volts and delivering from 0 to 150 ma.; C supply continuously variable from 0 to 150 volts and delivering from 0 to 5 ma.; filament supply delivering 6.3 volts, 10 amps. Unit is designed for relay rack mounting or bench use.—*Kepco Labs.*, 131-38 *Sanford Ave., Flushing* 55, *N. Y.*

For more information circle **297** on inquiry card.

Dual-channel Rectifier

New assembly of two complete rectifying units assures uninterrupted operation of magnetic chucks, mag-

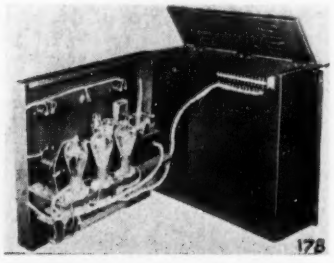


netic separators, d-c. motors, etc. Height 17 in., floor space 15 by 5.5 in. Current ranges: 2 to 10 amps.—*Electronic Rectifier Co., Rochester, N. Y.*

For more information circle **298** on inquiry card.

Three-phase Rectifier

New 3-phase 25-amp. rectifier has ammeter, voltmeter and switch on its



face. Ventilation is through louvres in top.—*Electronic Rectifier Co., Rochester, N. Y.*

For more information circle **299** on inquiry card.

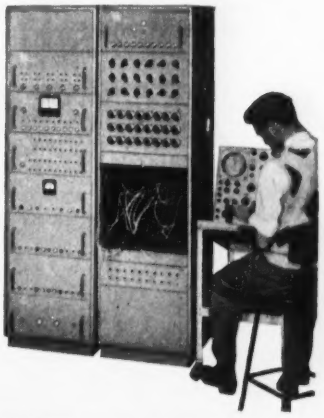
Constant-speed Power Unit

New "Type PMGG-X10 Power Package," originally intended for accurate timing and programming in aircraft and missiles, can be used in numerous ground applications. It comprises a permanent-magnet motor, a governor, and a gear train; fits into a volume of approx. 2.25 in. cube; oper-

working with differential equations?

***Electronic Analog Simulating Equipment**

Typical low-priced EASE COMPUTER installation showing 20-channel operational amplifier and power supply, 2-channel function generator, 3-channel function multiplier, typical variable component and over-voltage panel, 30-channel problem board.



SOLVES HIGH-ORDER EQUATIONS IN 1 TO 2 HOURS . . . when solution of relatively high-order differential equations is a customary part of your research or engineering work, the EASE computer can quickly pay its way. Solution time for equations up to the 20th order, *including set-up*, is only one to two hours!

SIMPLE TO OPERATE AND MAINTAIN . . . any engineer or mathematician who can set up the equation can solve it on the EASE computer with only a few hour's training. Circuitry is no more complex than the average radio receiver; no "computer experts" are required for maintenance.

COMPACT, COMPLETELY SELF-CONTAINED . . . the entire unit requires less than 8 sq. ft. of floor space, is complete with its own regulated power supply . . . you simply plug it in to a 20 ampere, 110 v. a.c. line!

LOW COST . . . the EASE is the world's first high-quality computer to be mass-produced in practical commercial form. The result is low cost without sacrifice in utility or quality. A 20-channel unit capable of solving 10th order equations costs less than $6,250 (f.o.b. factory) complete!

For complete data, please request Bulletin 507

Berkeley Scientific

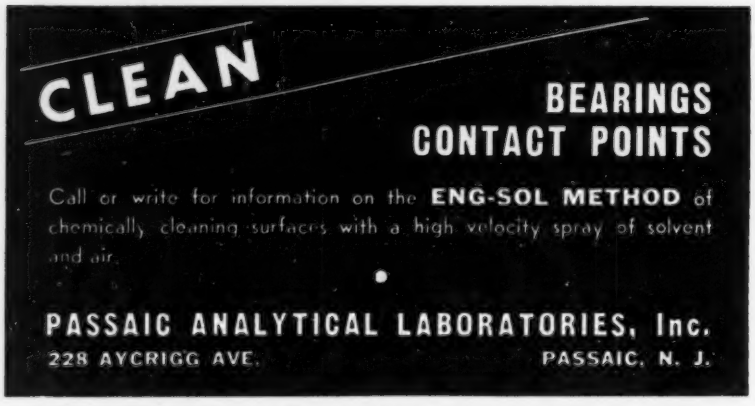
division of BECKMAN INSTRUMENTS INC.

2200 WRIGHT AVENUE • RICHMOND, CALIFORNIA

M-9

For more information circle **79** on inquiry card.

Victoreen
. . . PRESENTS
2 NEW COUNTER TUBES
THE POPULAR 1B85 . . . 5 TIMES STRONGER
THE NEW 6306 . . . A HIGH EFFICIENCY COMPANION
The widely used 1B85 beta-gamma counter tube is now stronger and more durable than ever before. Improved design of the aluminum shell provides three times as much resistance to point or finger pressure and the tube is five times stronger over-all. Greater strength, uniformity in construction, simplicity of mounting and high performance at lowest cost are qualities that assure maximum satisfaction in most applications. Price: $7.50.
Victoreen also announces the new type 6306 Bismuth-cathode counter tube which is five times more efficient than ordinary tubes on I_{131} and twice as efficient on Radium. The new 6306 tube has the same dimensions and electrical characteristics as the new 1B85 tube. Price: $15.00.
NOTE THESE ADVANTAGES
SMOOTH WALL for easier cleaning . . . handling . . . immersion . . . mounting.
UNIFORMITY for interchangeability without circuit adjustments . . . parallel operation without decoupling.
LOW COST for multiple tube applications such as cosmic research . . . aerial prospecting . . . hand and foot monitors . . . laundry, area and process monitors.
WRITE FOR FACTUAL DATA SHEETS ON THESE AS WELL AS YOUR OTHER COMPONENT REQUIREMENTS
The Victoreen Instrument Co.
3800 PERKINS AVENUE
CLEVELAND 14, OHIO
For more information circle 80 on inquiry card.


CLEAN
BEARINGS
CONTACT POINTS
Call or write for information on the ENG-SOL METHOD of chemically cleaning surfaces with a high velocity spray of solvent and air.
PASSAIC ANALYTICAL LABORATORIES, Inc.
228 AYCRIGG AVE.
PASSAIC, N. J.
For more information circle 81 on inquiry card.

For more information circle 82 on inquiry card.

ates on nominal 27.5 v.dc. Speed constancy is within 0.33 percent for 10 percent voltage variation; current consumption approx. 0.25 amp.; high starting acceleration makes it become stable in a few milliseconds. Output shaft rotates at 1.33 rpm., torque up to 100 inch-ounces (other speed and torque ranges available; also slip clutches and electromagnetic clutch and brake combinations).—*Pacific Instruments & Controls Co., 2317 Westwood Blvd., Los Angeles 64, Calif.*

For more information circle 300 on inquiry card.

ELECTRICAL AND ELECTRONIC COMPONENTS

Printed-circuit Units

New printed-circuit resistor and *RC* networks are trade-named "Mummies" because of new insulating process which seals units in a series of humidity and atmosphere barrier layers forming a tight unitary insulating shell. Insulation consists of four layers: two filled organic resins, and two thin impervious "skins" of hard inert inorganic matter. Shelf life stability is better than 99 percent. Load life, noise and resistance-temperature characteristics are improved by 15 to 25 percent over those of conventionally insulated elements. Temperature characteristics of high-*K* capacitors are greatly improved by minimization of effects of porosity and surface irregularity.—*Vacumet, Inc., 1267 Claybourn Ave., Chicago 10, Ill.*

For more information circle 301 on inquiry card.

Printed-circuit Inductors

New IF transformers, coils, and traps are made by a photo-etch process which permits mass production of identical circuits from a single negative; are intended for application in home TV receivers, but process can be used to print circuits for components used in a wide range of radio and communications equipment.—*Tube Dept., RCA Victor Div., Radio Corp. of America, Camden, N. J.*

For more information circle 302 on inquiry card.

TV Line Equalizers

New "Series 400 Line Equalizers" comprise three types: "Models 423 and 431," for use in community TV systems, have standout type N connectors and accurately match 75 ohms at both input and output to prevent reflections. "Model 413" is equipped with miniature connectors for use in large apartment house and hotel systems.—*Spencer-Kennedy Labs., Inc., 186 Massachusetts Ave., Cambridge 39, Mass.*

For more information circle **303** on inquiry card.

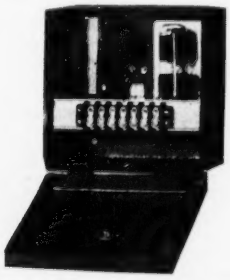
Pulse Transformers

New miniaturized pulse transformers for blocking oscillator applications are available in three styles: (1) plug-in octal base construction; (2) hermetically-sealed MIL-T-27 construction; and (3) encapsulated version with a built-in solder seal for chassis mounting. Choice of several different wiring connections.—*Raytheon Mfg. Co., Waltham, Mass.*

For more information circle **304** on inquiry card.

Supersensitive Relays

New "Ultra Sensitive Relays" have been designed especially for temperature control, automatic gaging and counting, etc. With unique new circuit, primary element (thermometric, etc.) does not carry more than 0.1, 0.01



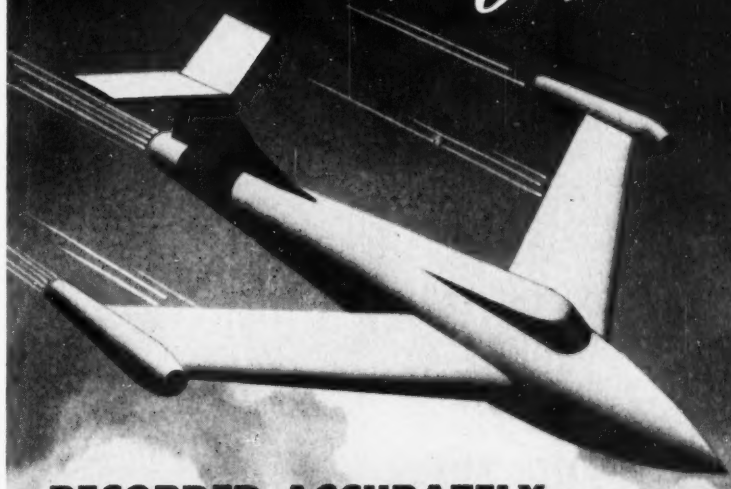
or even 0.001 microamp. (depending on circuit) through 500 megohms while hermetically-sealed snap-action relays carry as much as 30 amps. Eight different standard models are carried in stock.—*Devtronics, Inc., 221 N. Hermitage Ave., Trenton 8, N. J.*

For more information circle **305** on inquiry card.

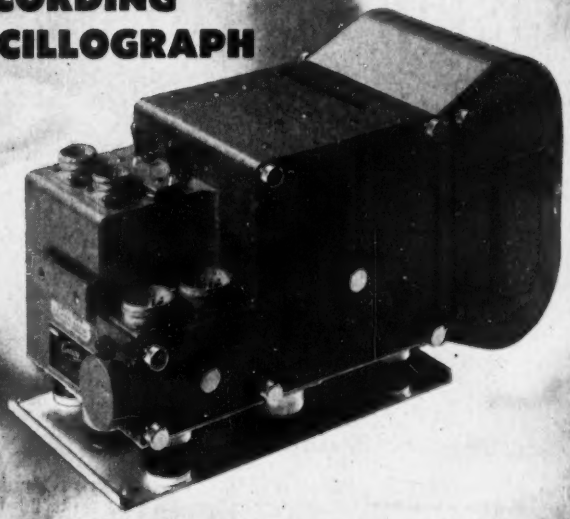
Electronic Relay for use with Mercury Thermoregulators

New "Elphco Electronic Relay Model No. 3" was designed originally for use with mercury thermoregulators. When control contacts are closed, current from relay's non-inductive control circuit does not exceed 1 microampere; when control contacts are

STABILITY *in flight*



RECORDED ACCURATELY
By Century Model 409
RECORDING
OSCILLOGRAPH

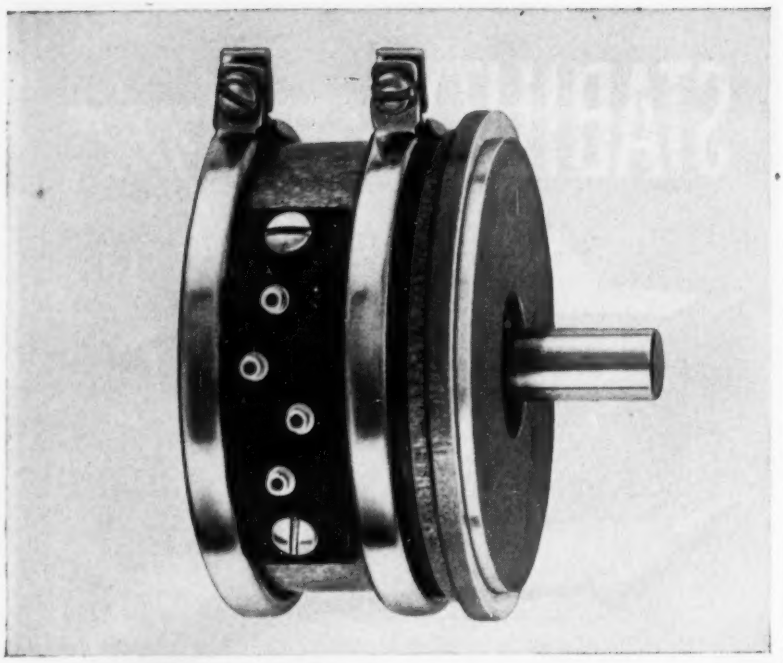


The Century Model 409 Oscillograph was designed for operation under the most adverse conditions, especially where space and weight considerations are limited. It is a miniature, compact unit incorporating many features found in larger models. Records faithfully during accelerations and shock in excess of 20 G's. Its size and capacity make it especially desirable for use in missile launching, parachute seat ejection, flight test of helicopter and fighter aircraft and torpedo studies.

Century GEOPHYSICAL CORPORATION
TULSA, OKLAHOMA

4447 No. Bodine, Philadelphia 40, Pa. | 3406 W. Washington Blvd., Los Angeles 16, Calif. | 238 Lafayette St., Dayton 2, Ohio | 309 Browder St., Dallas, Texas | EXPORT OFFICE 149 Broadway, N. Y. City

For more information circle **83** on inquiry card.



TYPE 756–
Fairchild's latest single-turn
PRECISION POTENTIOMETER
Gives you all these advantages...

1 Extremely low noise level and longer life with sustained high accuracy result from improved windings and wiper design. These improvements also permit higher rotational speeds with minimum of wear.

2 Higher resolution (0.05% at 2,000 turns) and close functional tolerances (linear ±0.25%; non-linear 0.35% with 3:1 slope ratio in high resistance ranges) give higher point-to-point tracking qualities.

3 Standard electrical functional angle is 320 deg. nominal with ORV tolerance of ±5% in resistance range from 800 to 40,000 ohms. Electrical functional angle of 350 deg. nominal with ORV tolerance of ±3% in resistance ranges of 50 to 45,000 ohms can be supplied on special order.

4 Greater flexibility—For non-linear functions as many as 13 taps can be provided by adding extra terminal boards.

5 All the desirable qualities of the well-known Type 746 unit, including easy and more accurate phasing, ganging up to 20 units on a single shaft, all-metal precision-machined housing and shaft, low torque, etc., are included in the Type 756.

Full information about the entire line of Fairchild Precision Potentiometers, including specifications of the Type 756 unit and how we can help solve your potentiometer problems, is available for the asking. Write to *Potentiometer Division, Fairchild Camera and Instrument Corporation, Park Avenue, Hicksville, Long Island, New York, Department 140-39B.*

FAIRCHILD
PRECISION POTENTIOMETERS

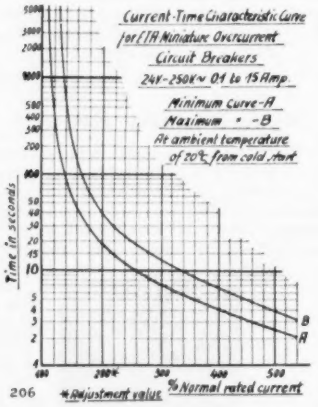
For more information circle **84** on inquiry card.

open, emf. from relay's control circuit does not exceed 6 volts. Power circuit safely controls heater load up to 1200 watts.—*Electro-Physics Co., 287 Broadway, New York 7, N. Y.*

For more information circle **306** on inquiry card.

Automatic Circuit-breakers

New "Thermo Automatic Miniature Circuit Breakers" (made in Germany) embody postwar patents; are designed to protect a-c. motors, small transformers, instruments, communications equipment, etc. Max. voltage ratings 250 v.ac. and 24 v.dc.; current ratings from 100 ma. to 25 amps. (If expected

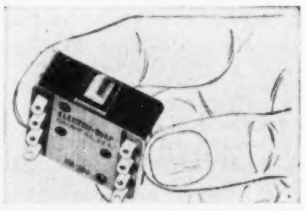


short-circuit current does not exceed 6 amps., breaker can be used for 230 v.dc.) Among features: amply-rotated bimetal overload device, simple release mechanism, push-button re-closing, easy incorporation into instruments, exceptionally long service life.—*E-T-A Products Co., 915 W. Oakdale Ave., Chicago 14, Ill.*

For more information circle **307** on inquiry card.

Double Switch

New "Double-pole Precision Switch" permits switching circuits having two different currents, phases or voltages, which must be switched at the same time. It can be used as

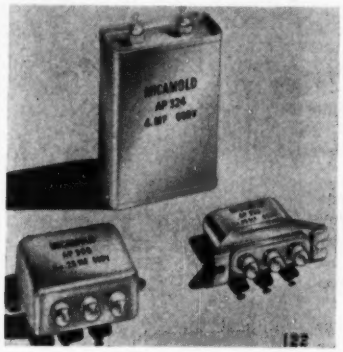


an inexpensive start-and-stop or limit switch on three-phase machinery. Said to be "the only double-pole switch to have eight terminals," it can operate as many as four separate circuits at one snap. It is rated for 15 amps. at 125/250 v.ac. and 10 amps at 30 v.dc. —*Electro-Snap Switch & Mfg. Co., 4220 W. Lake St., Chicago 24, Ill.*

For more information circle **308** on inquiry card.

150-deg. Capacitors

New "Ambirite" hermetically-sealed metal-encased capacitors, said to be the first capacitors ever developed for long and satisfactory operation in am-

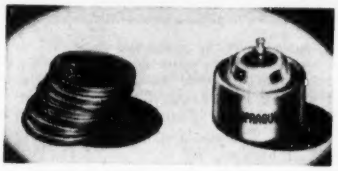


bient temperatures up to 150 C., can be supplied with single and dual sections in standard capacitance values and voltage ratings in various case sizes.—*Micamold Radio Corp.*, 1087 *Flushing Ave., Brooklyn* 37, *N. Y.*

For more information circle **309** on inquiry card.

Low-leakage Capacitors

New "100D Tantalex" hermetically-sealed tantalum electrolytic capacitors are designed for military and

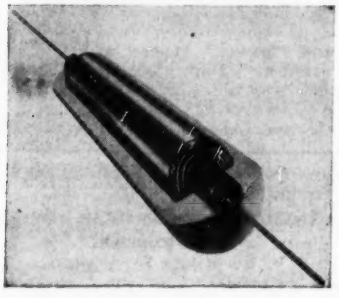


industrial applications where low leakage is primary requirement. Ratings are available for 85 C. or 125 C. continuous operation.—*Sprague Electric Co.*, 343 *Marshall St., North Adams, Mass.*

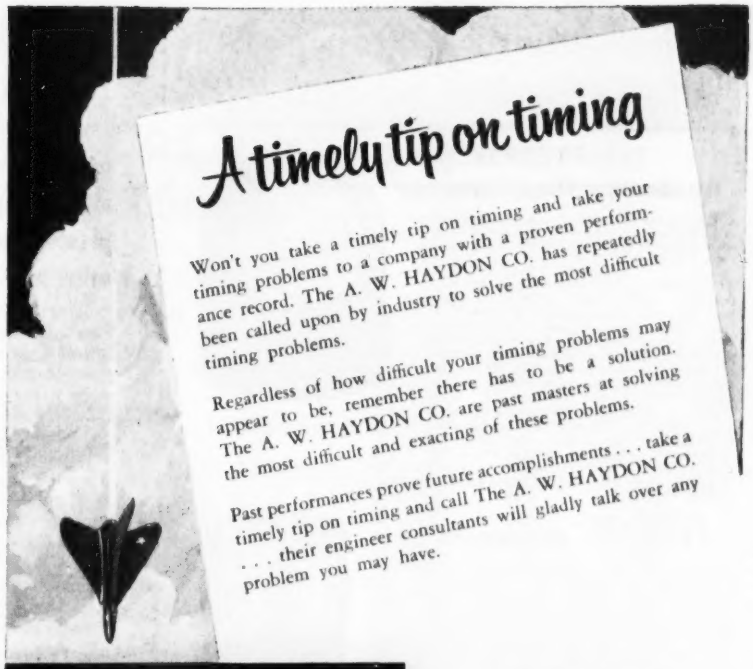
For more information circle **310** on inquiry card.

Molded Capacitors

New "Blue-Point Capacitor" is said to represent "a completely new concept in the design, construction and performance of molded plastic paper capacitors." Units are sealed against heat and moisture by means of a



glasslike thermosetting bond that becomes part of molded plastic case; are mineral-oil-impregnated for continuous operation at 85 C.; are produced


A timely tip on timing
Won't you take a timely tip on timing and take your timing problems to a company with a proven performance record. The A. W. HAYDON CO. has repeatedly been called upon by industry to solve the most difficult timing problems.
Regardless of how difficult your timing problems may appear to be, remember there has to be a solution. The A. W. HAYDON CO. are past masters at solving the most difficult and exacting of these problems.
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PREFERRED WHERE PERFORMANCE IS PARAMOUNT

For more information circle **85** on inquiry card.

Sylvania Offers FULL-LINE of High Quality Sockets
Sylvania now offers a full line of sockets for military and civilian requirements, manufactured in accordance with JAN and RTMA specifications. Available in General Purpose and Low Loss Phenolics and Steatite, with Brass, Phosphor Bronze or Beryllium Copper Contacts. Available types include 7- and 9-pin Miniature, Octal, Duo-Decal, etc., sockets. For complete descriptions write today for new illustrated catalog to: Sylvania Electric Products Inc., Dept. 3A-4207, 1740 Broadway, New York 19, New York.
JAN 7-Pin Miniature Socket
RTMA 9-Pin Miniature Socket (Shield base type)
Octal Socket (Top Mounting)
7-Pin Miniature Socket (Bottom Mounting)
Duo-Decal Socket
SYLVANIA
LIGHTING • RADIO • ELECTRONICS • TELEVISION
In Canada: Sylvania Electric (Canada) Ltd., University Tower Bldg., St. Catherine St., Montreal, P. Q.

For more information circle **86** on inquiry card.

Instruments for Measuring AIR TEMPERATURE and VELOCITY

TEMPSCRIBE Recording Thermometer

Available in 10 different ranges to cover −30°F to +160°F temperatures, and with spring-operated chart drives for any of the following chart rotations: 8 hours, 24 hours or 7 days.

This entirely self-contained, compact and reliable temperature recorder automatically writes a continuous record of temperature changes on a replaceable chart. Record shows at a glance maximum and minumum temperatures and the duration of temperatures above or below any given point; also shows the exact time of every temperature change and how rapidly it takes place. Recording pen and bi-metallic element are built in hinged, removable door which is also front of instrument. Thus, by merely changing doors it is easy to interchange temperature ranges. Instrument is 8" tall, 5½" wide and 4½" deep. Charts are 4½ inches in diameter.

Write for Bulletin I-715

FLORITE Anemometer

In principle, this unique instrument operates as an anemometer but provides instantaneous, direct readings of air velocity without timing, calculations or reference to charts. Readings are obtained by holding the instrument in the air stream so that air blows against its circular face, causing rotation of a multi-blade rotor mounted in instrument housing. The circular scale surrounding the rotor instantly turns to correct air velocity reading under an index pointer on scale window. Furnished with detachable handle (not shown) and leather case.

Available in two styles: One with a scale of 0-1000 ft./ min., and the other with a double scale of 0-3000 ft./min. and 0-35 miles per hour.

Write for Bulletin I-760

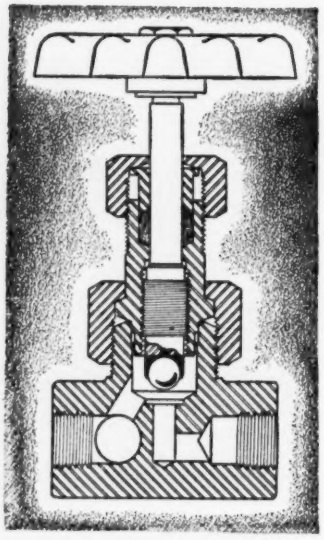
BACHARACH Industrial Instrument Co.

7301 PENN AVENUE • • PITTSBURGH 8, PA.

For more information circle **87** on inquiry card.

NEW! BALL VALVE

for air lines, meter manifolds, pressure gauges, other services



Here's a radically-new forged steel valve that can't leak . . . practically never wears out . . . costs less than ordinary steel valves.

In place of a disc or plug, the new Foxboro Ball Valve has a retained, free-rolling stainless steel ball that exposes new surface to seat at every closing.

Foxboro Ball Valves handle pressures to 3000 psi. Available in straight-thru and angle types. Two or four connections to simplify piping. ¼" size. Write for detailed folder.

The Foxboro Company, 467 Norfolk Street, Foxboro, Mass., U.S.A.

FOXBORO INSTRUMENTATION

For more information circle **88** on inquiry card.

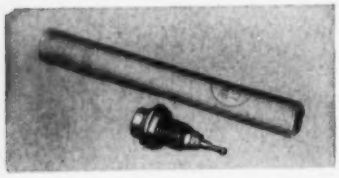
NEW INSTRUMENTS

in all popular ratings and sizes; individually tested.—*Astron Corp.*, 255 *Grant Ave., E. Newark, N. J.*

For more information circle **311** on inquiry card.

Test Point Jacks

New "45E Series Test-Point Jacks" (also called terminal jacks) accommodate standard 0.081-in. diam. phone tips, are 15/16 inch over-all (photo



shows unit and cigarette). Extended Nylon insulation at rear affords high flashover values averaging 4000-v. 60-cps. rms. Capacitance is 5 to 7 uuf.; contact resistance 6-8 mv./amp. Identification colors: white, red, black, brown, green, orange, blue.—*Cannon Electric*, 3209 *Humboldt St., Los Angeles* 31, *Calif.*

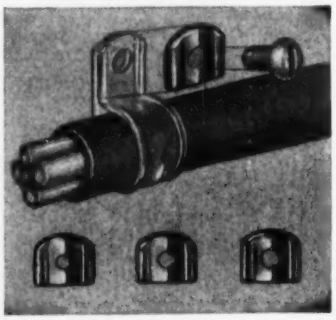
For more information circle **312** on inquiry card.

Tubular Capacitors

New "Glassmike, Jr." line of tubular capacitors for commercial radio and TV filter and bypass use is similar in construction to "Glassmike" line. Features are tubular glass case, oil impregnation and plastic dielectric section good for temperature requirements to 100 C. Units are available in 400, 600, and 1000 v.dc. ranges and in capacitance from 0.001 uf. to 1.0 uf.—*Condenser Products Co.*, 7517 *N. Clark St., Chicago, Ill.*

For more information circle **313** on inquiry card.

Cable-clip Washer



New "D" washer is for use with maker's line of plastic cable clips.—*Weckesser Co.*, 5261 *N. Avondale Ave., Chicago* 30, *Ill.*

For more information circle **314** on inquiry card.

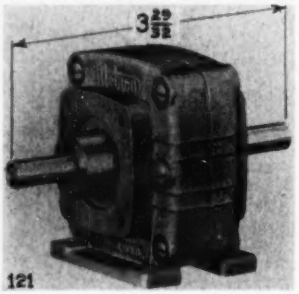
Tubular Capacitors

New "Plastimike" is said to be the first all-plastic tubular capacitor for commercial market (previously, only special assignment war and defense items). Units have Dapite plastic case. Mylar dielectric good to 125 C., and epoxy resin seal. Insulation resistance 100,000 megohms minimum. Ratings run from 0.001 to 1.0 uf. in 400, 600 and 1500 v.dc. ranges.—*Condenser Products Co.*, 7517 *N. Clark St., Chicago, Ill.*

For more information circle **315** on inquiry card.

Small Speed Reducers

New "Bantam Series 10" speed reducers fill in gap between "miniature"



and "power" types; are nominally rated at 0.1 hp. More than 600 ratios are available.—*Metron Instrument Co., Denver* 9, *Colo.*

For more information circle **316** on inquiry card.

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August 10-14

Gordon Research Conference on Analytical Chemistry, New Hampton School, New Hampton, N. H. For information write W. George Parks, Director, Chemistry Dept., University of Rhode Island, Kingston, R. I.

August 17-27

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August 19-21

IRE Western Electronic Show and Convention, Municipal Auditorium, San Francisco, Calif.

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Appalachian Gas Measurement Short Course, West Virginia University, Morgantown, W. Va. For information write G. W. Stuart, Equitable Gas Company, 3325 Hyperion St., Pittsburgh 14, Penna.

September 9-11

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September 9-11

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September 21-25

Eighth National Instrument Conference & Exhibit, Sherman Hotel, Chicago, Ill. For information write P. V. Jones, Mgr., Instrument Society of America, 1319 Allegheny Ave., Pittsburgh 33, Pa.

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Ninth National Electronics Conference and Exhibition, Sherman Hotel, Chicago. For information write Karl Kramer, Executive Secretary, 852 E. 83 St., Chicago 19, Ill.

Oct. 14-16

Midyear Meeting of Recorder-Controller Section, SAMA, Seaview Country Club, Absecon, N. J.

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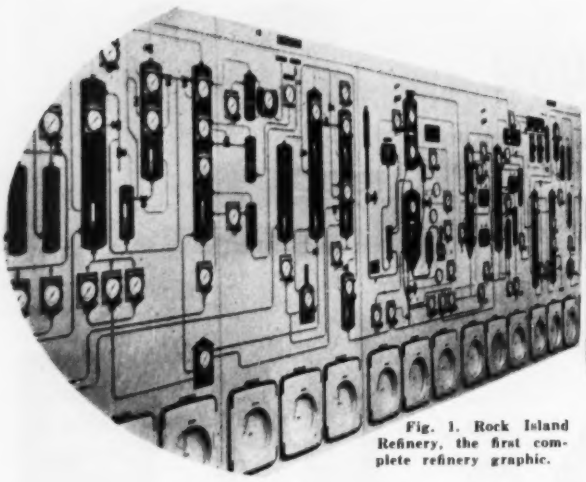


Fig. 1. Rock Island Refinery, the first complete refinery graphic.

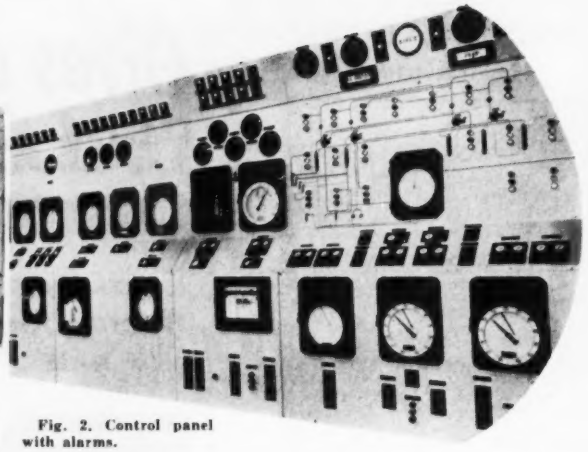


Fig. 2. Control panel with alarms.

PROCESS MONITORING

New techniques with standard components—scanners, annunciators, digital converters, and automatic typewriters—are making possible the monitoring of hundreds or thousands of individual points in continuous processes, and are opening new frontiers for centralized control, cost accounting, complete automation, and process research.

by ALBERT F. SPERRY
Panellit, Inc.

LIMITS to the application of truly automatic control have been imposed by the sheer complexity and volume of information which must first be converted to usable messages and then stored away in such a manner as to be readily available when needed for comparison with other information.

The storing of information and the "remembering" when needed is one of the difficult things for a machine to do, particularly when the amount of information becomes large and involved. No machine ever built can receive information and retain it with a fraction of the efficiency with which it can be done by the human brain. (The recent developments in transistors have led us to expect that more and more compact memory devices might be available in the near future.)

The human operator will play an essential part in the automatic control of large processes for a long time to come. The best evidence that this tendency is generally accepted by industry lies in the amount of attention that has been given to the modern central-control panelboard, which is the most effective way of presenting process information to an operator.

Although the human brain can store up and remember tremendous masses of information over long periods of time, it becomes confused when it is required to translate this information into intelligent response at a high speed. In this respect the machine is better; with the aid of modern electronic devices it can perform operations within its capabilities at almost limitless speeds.

The ideal combination of man and machine will be the one in which the man will use his brain to analyze, form judgments, and initiate commands, while the machine takes over all of the information-gathering and repetitive control operations where its inherent capabilities of speed and power are most effective.

Presented at the Eighth Annual Symposium on Instrumentation in the Process Industries, Texas A & M College, College Station, Texas, January 1953.

Basic Concept and Function

Basic to the concept of process monitoring is the fact that most of the information gathered by the instruments associated with a continuous process is of little practical use to the operator except during periods of disturbance or danger. The actual hour by hour, minute to minute control of even a complex process under "normal" operations involves the supervision of a relatively few significant variables. The automatic controllers and the inherent stability of the process keep the bulk of the quantities in proper relationship—most of the time.

Unfortunately, unbalances and disturbances occur at the most unexpected times. When they do occur the operator may need a great deal of detailed information about one small section of the process so that he can make the corrective action required to return the process to equilibrium.

The function of a well-designed process-monitoring system is to enable the operator to concentrate, in a relaxed manner, on the entire system during normal periods; and to call his attention to any detailed abnormalities as soon

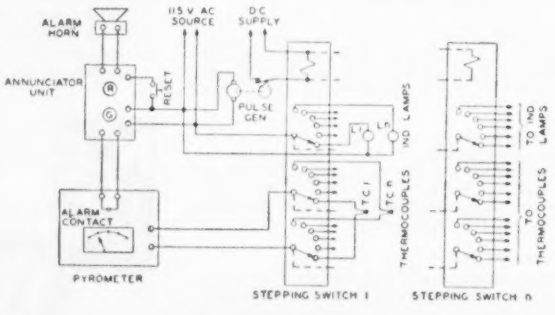


Fig 3. Basic scanning system.

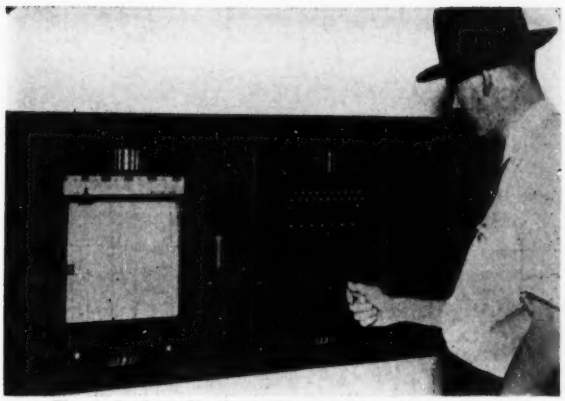


Fig. 4. Leeds & Northrup 160-point temperature scanner.

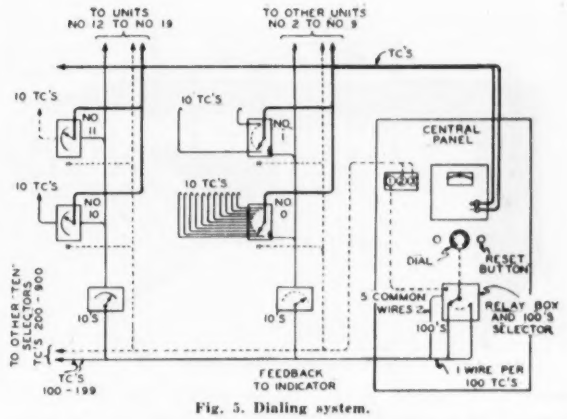


Fig. 5. Dialing system.

as they are detected so that he can transfer his attention temporarily to the part of the process being disturbed. In addition, the monitoring system may have secondary functions, such as data recording (to form a basis for long term research and study), cost accounting, etc.—but its primary function is in its role of extending the scope of a single operator to ever larger and more continuous processes.

The first comprehensive attempts to monitor a complete process were made during World War II in connection with certain national defense projects. Shortly after the war the broad principles were outlined in a group of talks and a paper by F. H. Trapnell (*Instruments* magazine, 1947) on the design of centralized control systems. Many of the concepts described below stem from the clear restatement made in those papers of the importance of putting large masses of information before a single operator.

We will discuss four general methods for applying the principles of process monitoring to a modern plant—(1) graphic flow-sheet panelboards, (2) annunciator systems, (3) automatic scanning systems, and (4) automatic recording systems.

Graphic Panelboards

The development of miniature instruments and control stations has made it possible to crowd a great many instruments before a single operator. As there is a limit to the amount of information to which an operator can react intelligently, particularly during upsets and times of stress, it is necessary to apply visual aids on the panelboard. This has resulted in the development of the *flow-sheet graphic panel* as a basic central-control-room design.

Fig. 1 shows how a complete refinery process can be integrated before a single operator. Although this panel was the first such unit placed in operation (July, 1949), it is still one of the outstanding examples of process monitoring by this method. It is possible for one man, standing before the board, to watch the progress of a disturbance through the whole system and intelligently select corrective action which will bring the system back to equilibrium smoothly and without creating secondary upsets, such as might be caused by too-sudden application of controls. A man with relatively little background as an operator can function with a minimum of training in a central control room of this type.

Annunciator Systems

Alarm, or annunciator, systems were conceived originally as danger signals and still serve an important function in monitoring processes for hazardous conditions. A relatively few carefully placed alarms usually can warn against malfunctioning of process equipment.

Fig. 2 shows a section of a control board for a complex chemical process in which the alarm system is used as an operating guide as well as a warning system. The panelboard is a conventional type using standard pneumatic recorder-controllers. The annunciators are located on the sloping panel at the top; each annunciator is located directly above the recorder-controller to which it is related. The annunciators are operated by pressure switches which are connected to the controller output pressure. As soon as the output pressure to any valve goes beyond the predetermined point, a buzzer is sounded and the operator is warned. This warning often comes before the actual measured variable deviates very far, particularly in temperature, level, and some pressure controllers. A sticky valve or some fault in the controller will show up in this manner before any trouble shows up in the process. The output pressure may change considerably even though the valve itself may not actually move.

A process monitored in this way leaves the operator free to watch the few critical points almost continuously. Any abnormality will sound the buzzer and call his attention to the fact that something is not behaving in the normal

Scanner Design Chart

The particular combination depends on the type and amount of information that must be presented to the operator and the equipment which he must operate.

Primary Element	*Switching System*	*Measuring System*	*Position Indices*	*Alarm Indication*	*Measurement Indication*	*Recorders*	*Manual Setting Devices*	*Auxiliaries*
Thermocouple	Electrically operated stepping switches	Galvanometer	Lamps for each point	Annunciator and horn	Continuous or abnormal only	Circular, strip, or segmental chart	Telephone dial	High-speed secondary scanners
Resistance bulb	Relay train	Null potentiometer	Lamps, coordinate	Coordinate lamps	Synchros	Automatic typewriter or printer	Manual coordinate seeking or point seeking	Recorders or indicators
Diff. transformer	Mercury jet switch	Amplifier	Pulse indicators	Gas tubes	Galvanometers	Perforated tape or card	Variable speed	Interconnection patching panel
Capacitor	Motor-driven switch		Telemeters	Telemeters	Potentiometers	Magnetic wire or tape	Bank or row bypass or repeat	Hi-lo control
Any electrical transducer				Graphic light displays	Oscilloscope	Photograph	Group or individual alarm limit adjustments	Panelboard or console

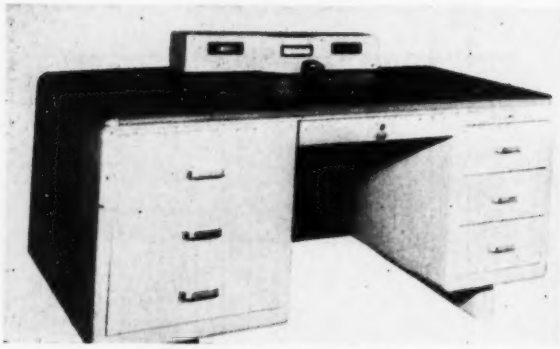


Fig. 6. Dialing-system console.

manner. Of course, if real danger occurs, then a siren is sounded by a separate alarm system or, as may be noted on the right-hand panel of this group, a complete shutdown system protects the entire unit.

Automatic Scanning System

The systems described have made it possible to have a single operator supervise a control room containing as many as three or four hundred controllers and instruments, with dozens of annunciator points acting as "watch dogs" twenty-four hours a day. However, as the number of points to be monitored grew into the thousands, even this system became too bulky and costly. It also became evident that many of the variables measured often had no significance to the operator except during periods of disturbance. This led to the development of the automatic scanner (Fig. 3).

The main elements are one or more *rotary stepping switches*. For temperature scanners, two banks of contacts are necessary to switch the thermocouples, and at least one more bank for switching the position-indicating lights. Thermocouple circuits are connected to a pyrometer or a detector which has an adjustable alarm contact, which actuates an annunciator system. When one of the points exceeds its predetermined limits it actuates the annunciator. This energizes an alarm light, sounds a horn, and stops the motor-driven pulser which drives the stepping switch. The operator notes the position of the scanner by its indicating lights. He then presses the reset switch, which permits the scanner to proceed.

Commercial Units

The first standard temperature monitor was developed by the Leeds & Northrup Company (Fig. 4). It has eight banks, each containing twenty temperatures. In addition it is equipped with a strip-chart recorder which can print each point. A numbering wheel shows the bank and number of each point as it is printed. If any point deviates beyond the high or low limits, an alarm is sounded through a standard annunciator system.

Other standard scanning systems have become available, such as the Minneapolis-Honeywell 270-point temperature scanner and the Thomas A. Edison 25-point temperature scanner.

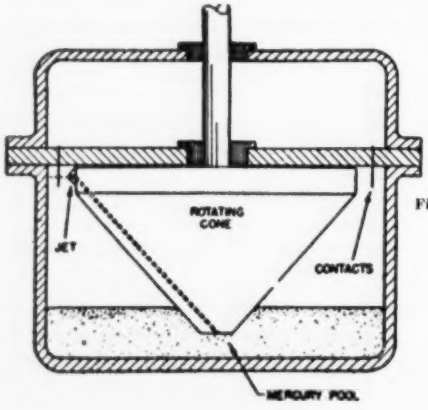


Fig. 7. Jet switch.

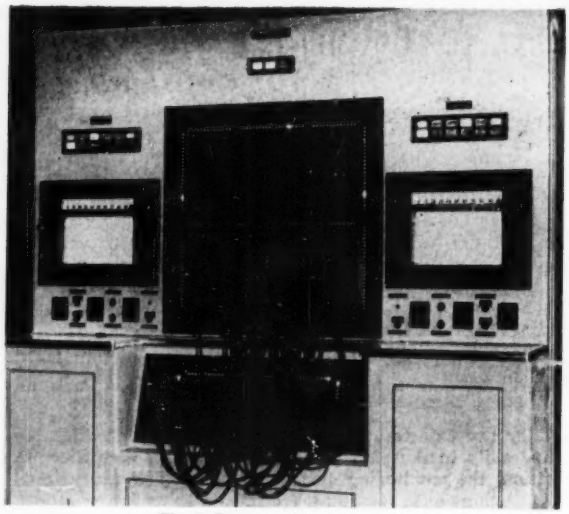


Fig. 8. Scanner with jack panel.

Sun Oil System

An extremely flexible system was developed by Sun Oil Company and extensively utilized in its Marcus Hook and Toledo plants. (This system is described completely in the paper by E. J. Grace, Jr.—Paper No. 50-2-2 presented September, 1950, ISA Conference.)

The stepping switches are in a decade system so that the numbering system is a standard decimal arrangement. It usually is made up with a master circuit capable of handling up to a thousand units, with a separate stepping switch required for each ten units. Instead of indicating lamps for registering the position of the scanner, two index-systems have been developed. One is a resistance network operated by the stepping switches, with three indicating-millivoltmeters to show the position of the switches in hundreds, tens, and units. The other system uses an electric impulse, fed back from the stepping switch to a solenoid-actuated position-indicator located at the panel.

This system has several advantages in flexibility. First, the stepping switches do not have to be located on the main panel; they are usually grouped in weatherproof boxes at the foot of the towers or near the equipment which they are monitoring. Therefore thermocouple lead-wire need only be run to the individual stepping switches, which are connected to the main panel with a single cable consisting of five common wires and one extra wire for each 100 thermocouples, plus one pair of thermocouple leads. This saves on installation and lead wire in a large plant, but requires great care in weather-proofing the field-mounted stepping switches.

A second advantage lies in the ability to replace the motor-driven pulser with a standard telephone dialing mechanism (Fig. 5). The operator can dial directly and connect his instrument to any of the thermocouple points at will. Logging of temperatures is a simple operation. It is not necessary to re-dial each number; merely by adding one pulse the system keeps progressing steadily as fast as the operator can read it. Fig. 6 shows an up-to-date version of this system mounted in a standard desk console.

Stepping Switches

For dialing systems, stepping switches should be of the decade type; for thousands of thermocouples it may be more economical to use the 26-point multiple-bank switches. Either type is standard telephone equipment. Contacts must be made with gold-plated tips to give positive operation.

Although stepping switches have been used at speeds up to 75 points per second, their use in scanning systems is limited to much less than this. The main limitation lies in the fact that at extremely high speeds (over 10 points per second) the noise level due to switching and interferences

Continued on page 1038

Sizing Control Valves Handling Flashing Liquids

Conventional heat-balance methods of sizing control valves handling flashing liquids can be seriously in error. A method based on "apparent critical pressure drop" gives superior results for globe bodies.

By GLENN F. BROCKETT and CHARLES F. KING
Fisher Governor Co.

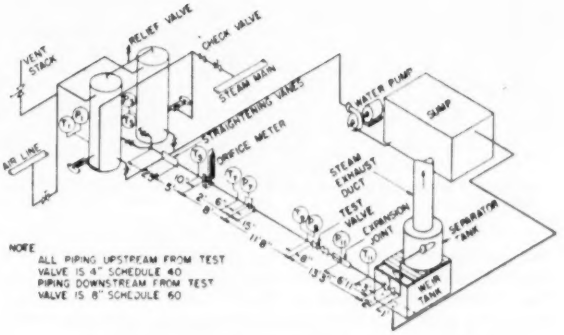


Fig. 1. Laboratory arrangement for flashing tests.

CAPACITY of control valves handling liquids has generally been determined from the fundamental law of fluid flow, $V = \sqrt{2gh}$. In most applications, calculations based on this fundamental law give accurate results, but it is possible to have conditions of temperature and pressure such that the deviation from this law is too great to be disregarded.

There has been no generally accepted method of determining control-valve capacity when thermodynamic considerations indicate a mixture of steam and water at the outlet of the valve.

One method widely used, and sometimes referred to as the "heat balance" method, is based on the assumption that a certain percent of the vapor existing downstream from the control valve was flashed in the body, and the port area is made sufficiently large to pass the liquid plus the arbitrarily chosen percentage of flashed vapor. The percentage of vapor flashed in the valve body is assumed to be between 50 and 100 percent of the total existing downstream. Another method that has been recommended is to make the valve one size larger if pressure and temperature indicate flashing in the body. These methods are based on guesswork and often lead to incorrect sizing.

In order to obtain test data from which an accurate method of sizing control valves handling hot water could be evolved, the Fisher Governor Company at Marshalltown, Iowa has run some laboratory tests that lead to interesting conclusions.

Test Equipment

Equipment used in running the tests is illustrated schematically in Fig. 1. Water was pumped into two 1,000-gallon storage tanks, indicated on the left of the illustration, and heated to various desired temperatures by the injection of live steam into the bottom of the tanks. Pressure was controlled by introducing compressed air near the top of the tanks. It was possible to obtain pressures ranging from nearly atmospheric to 200 psia., and temperatures from 70 to 350 deg. F.

Hot water from both storage tanks was piped into a single 4-inch metering test line. The test line contained straightening vanes, orifice flanges, hand-operated valve, the test valve, an expansion joint, a hand valve, and a separation tank, in that order. From the separation tank, steam was exhausted to the roof, and water was piped to the sump from which the pump took suction.

Pressure and temperature measurements were taken in the storage tank and at various points along the meter run, as indicated by the encircled "P" and "T" designations. Temperature measurements were made with iron-constantan thermocouples and recorded on a twelve-point high-speed recording potentiometer. Differential pressures up to 25 psi. were measured with differential mercury manometers, and static pressures were measured with Bourdon-tube test gages.

During a test run the static pressure of the water in the metering section of the test line was always maintained high enough to prevent flashing at the orifice plate. The test-valve inlet pressure was controlled by the hand valve located between the orifice plate and the test valve. The hand valve located downstream from the control valve was used to control the differential pressure.

All piping upstream from the test valve was 4-inch Schedule 40, and downstream from the test valve was 8-inch Schedule 60. Control valves ranging in size from 1 to 3 inches were tested and were installed in the test line with swages.

Angie bodies were tested in a similar arrangement, except for the piping change necessary for their installation.

Although we were primarily interested in studying the flow of water in the liquid state at the control-valve inlet, we were able to obtain some data with a water-steam mixture, and with all steam at the inlet.

Briefly, the method of testing was to maintain a constant pressure and temperature at the inlet to the test valve and to measure the flow with various differentials. This pro-

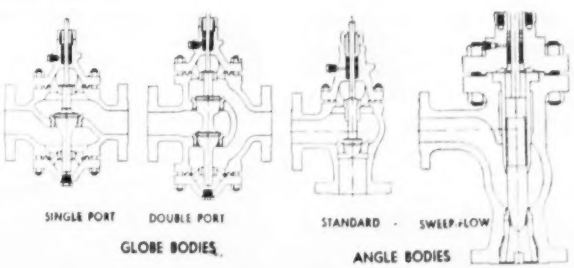


Fig. 2. Body types tested.

Presented at the Eighth Annual Symposium on Instrumentation in the Process Industries, Texas A & M College, College Station, Texas, January 1953.

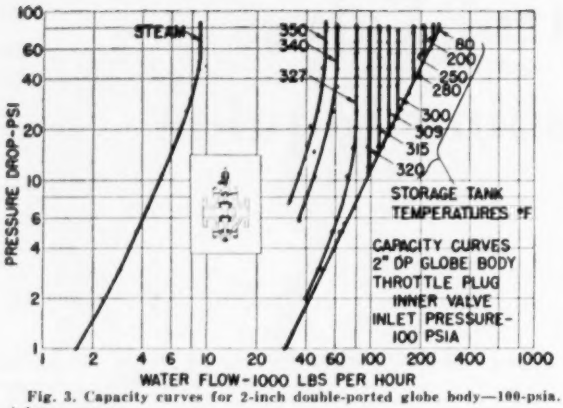


Fig. 3. Capacity curves for 2-inch double-ported globe body—100-psia. inlet pressure.

cedure was then repeated for other values of temperature and pressure at the valve inlet. As no condenser facilities were available, the lowest discharge pressure attainable was atmospheric. However, where trends were well established, we have felt it reasonable to assume that there would be no appreciable deviation for the last 15 psi. of pressure differential if the valve were discharging into a vacuum.

Preliminary tests indicated that flow through globe-style bodies (Fig. 2) did not follow the same laws as angle bodies. Consequently, globe bodies and angle bodies are discussed separately.

Globe Bodies

The results of a typical series of tests are illustrated in Fig. 3. The test valve was a 2-inch double-ported globe type, equipped with a plug-style inner valve. The inner valve was positioned at maximum lift, and the port area was approximately 90 percent of 2-inch pipe area. One-hundred-psia. pressure was maintained at the inlet to the test valve throughout the tests.

In order to study the deviation from the theoretical flow law, let us first examine the fundamental flow equation.

Fundamental Flow Law

The fundamental law of fluid flow commonly used in determining the capacity of control valves for liquid flow is:

$$Q = C_V\sqrt{\triangle P/G}$$

where Q is quantity flowing in gallons per minute, C_V is capacity of the valve with 1-psi. pressure drop in gallons per minute, $\triangle P$ is pressure drop from inlet to outlet of the valve in psi., and G is specific gravity of the flowing liquid. For convenience, this formula has been translated into nomographs, charts, slide rules, etc., by most valve manufacturers.

The straight diagonal line at the right of the family of curves in Fig. 3 follows this hydraulic formula.

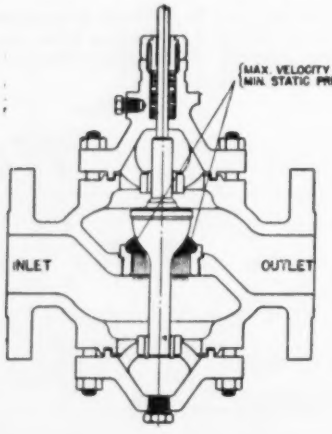


Fig. 4. Valve body cross-section showing points of high velocity.

Fig. 6. Allowable-pressure-drop curve for globe bodies.

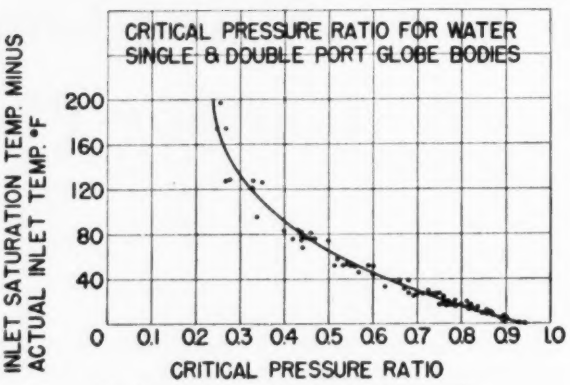

CRITICAL PRESSURE RATIO FOR WATER
SINGLE & DOUBLE PORT GLOBE BODIES
INLET SATURATION TEMP. MINUS
ACTUAL INLET TEMP. °F
CRITICAL PRESSURE RATIO

Fig. 5. Curve of apparent critical pressure ratio.

Test of Double-ported Globe Body

In Fig. 3, rate of flow is designated on the abscissa, and pressure drop on the ordinate. Note that the coordinates are logarithmic. Each curve represents a test run at constant temperature at the valve inlet. The storage-tank temperatures are marked on the curve. Saturation temperature for water at 100 psia. pressure is 327 F. As long as the temperature was maintained below 327 F. in the tank, and the pressure never went below 100 psia., the water remained in the liquid state up to the inlet of the test valve, and the water temperature remained substantially constant between the test valve and the storage tank. Consequently the temperatures on the curve to the right of the one marked 327 F. are valve inlet temperatures as well as storage-tank temperatures.

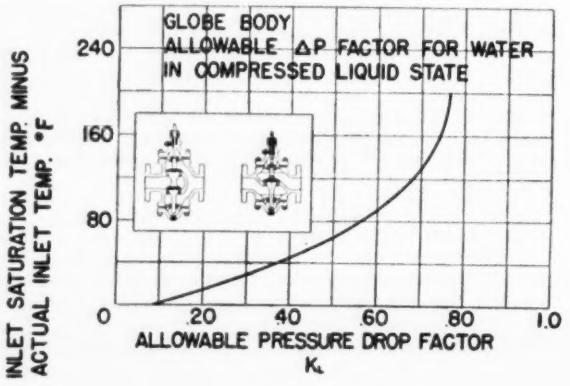
The curves to the left of the one marked 327 F. were plotted from tests with a mixture of steam and water in the test line between the upstream hand valve and the test valve. Consequently the temperature at the inlet of the test valve, being dependent on the 100-psia. pressure, remained at 327 F. regardless of the storage-tank temperature.

The curve at the extreme left in Fig. 3 shows results of a test run with saturated steam at the test-valve inlet and is shown to complete the illustration of the flow-rate vs. pressure-drop relationship for water in its various states.

Note that despite a general belief to the contrary, the flow curves indicate an apparent critical pressure ratio with liquid flow. The numerical value of this ratio varies with inlet temperature, but in every case where inlet temperature is below saturation (327 F.), it occurs at outlet pressures above saturation or with the water still in the liquid state.

Tests of 1, 1½, 2, 2½ and 3 inch globe-style control valves in both single- and double-ported construction and equipped with V-port and plug-style inner valves all yielded similar curves. These tests were run with 50, 100, and 200 psia. inlet pressures.

Note that even with relatively cold 80-deg. F. water, at a



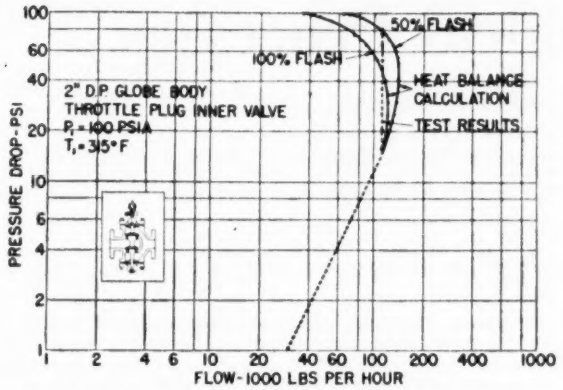


Fig. 7. Comparison of "heat-balance" method calculation results and actual capacity tests.

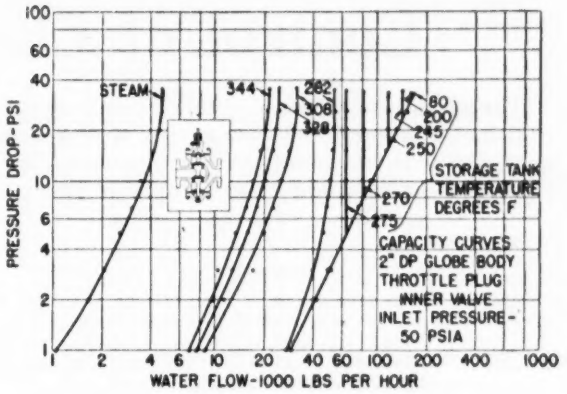


Fig. 8. Capacity curves for 2-inch double-ported globe body—50-psia. inlet pressure.

pressure differential of 75 psi., the rate of flow no longer increased with increasing pressure drop and the basic theoretical formula no longer applies. At 320 F. and 100-psia. inlet pressure, the maximum flow is reached at approximately 12-psi. differential. These tests indicate that serious errors can result from using the conventional hydraulic formula in sizing control valves handling warm or hot water.

Apparent Critical Pressure Drop

Gas flow through a valve or orifice reaches a maximum when the differential is increased to approximately 50 percent of the inlet pressure and remains substantially constant at greater differentials. This point at which increasing differential no longer results in increasing flow is called "critical pressure drop," and the ratio of outlet pressure to inlet pressure is called the "critical pressure ratio." Since water flows were found to exhibit a similar tendency, it is logical to call the pressure drop at which any one of these curves changes slope to vertical an "apparent critical pressure drop," and the ratio of outlet to inlet pressures an "apparent critical pressure ratio." Note that whereas gas has a relatively constant critical pressure ratio of approximately 0.5, these tests indicate that water at temperatures between 80 and 320 F. has an apparent critical pressure ratio that varies between 0.15 and 0.88.

A little thought makes the cause of this phenomenon fairly evident. As the liquid approaches the orifice of the control valve, its velocity increases and reaches a maximum at a point in the orifice outlet that corresponds to the vena contracta of an unrestricted orifice. As the velocity increases, the static pressure head is converted to velocity head. As the differential pressure is increased (and consequently the velocity) there eventually comes a time when the static pressure at the point of highest velocity is lowered to the vapor pressure of the liquid at the flowing temperature. When this point is reached, further increase in differential does not result in increase in flow because volumetric increase from vaporization more than nullifies any tendency toward velocity increase. This phenomenon is illustrated in Fig. 4.

A study of the curves such as shown in Fig. 3 of water flow versus temperatures reveals the fact that the fundamental hydraulic formula could be applied to a valve capacity problem if the limiting pressure drop for each temperature were known. All data taken on the various globe-valve body-assemblies tested were plotted; a study of the curves revealed a surprisingly uniform variation in apparent critical pressure ratio among tests with inlet temperatures varying between ambient and saturation.

The relationship between "inlet saturation temperature minus actual inlet temperature" and "critical pressure ratio" for approximately 100 different combinations of valve assembles, pressure conditions, and inlet temperatures is plotted on Fig. 5. Note that although the experimental points are somewhat scattered, the trend of the curve is well defined. This leads to the conclusion that with water flowing through a globe-style control valve, there will be an apparent critical pressure drop that is a function of the difference between saturation temperature and actual temperature at the valve inlet.

Fig. 6 is a re-plot of the basic data on Fig. 5 with "one minus critical pressure ratio" as abscissa. The expression "one minus critical pressure ratio," which might also be written "ratio of pressure differential to absolute inlet pressure," has been designated as "allowable pressure drop factor," or K_L. As

$$K_L = \triangle P / P_1$$

where K_L is allowable pressure drop factor from curve, $\triangle P$ is pressure differential at critical pressure ratio in psi., and P_1 is inlet pressure in psia., we may write:

$$\triangle P = K_L\ (P_1)$$

To illustrate how this formula may be used in the solution of a water-flow problem, assume that the inlet pressure is 120 psia., pressure drop is 60 psia., inlet temperature is 300 F., saturation temperature for 120 psia. is 341 F., and $\triangle t = 341$ minus $300 = 41$ degrees.

From Fig. 6, K_L is 0.38.

Therefore, the allowable pressure differential equals $(0.38)\ (120) = 45.6$ psi. Thus, if the control valve is being sized by use of the formula.

$$Q = C_v \sqrt{\triangle P / G}$$

or with a slide rule, nomograph, or capacity table based on this formula, 45.6 psi. should be used as the $\triangle P$ value, rather than 60 psi.

If the pressure drop in this problem had been less than 45.6 psi., the actual pressure drop should have been used.

Note that the allowable pressure drop factor curve in Fig. 6 asymptotically approaches the value of 0.75. From this we can conclude that globe bodies handling water should not be sized for pressure differentials greater than 75 percent of the absolute inlet pressure.

Test of Heat-balance Method of Sizing Valves

Fig. 7 shows a comparison of actual capacity tests with the "heat-balance" method of sizing valves. The curves pertain to data on a 2-inch double-ported globe body with a plug-type inner valve, inlet pressure of 100 psia., and temperature of 315 F.

The dashed line represents actual test data, and the solid lines illustrate the deviation from actual capacities that would be indicated by the heat-balance method, assuming 50 and 100 percent flash in the body. Assuming 50 percent flash, the heat-balance method could indicate a capacity 27 percent too high or 41 percent too low, depending on the pressure drop. Assuming 100 percent flash we could arrive at a capacity 9 percent too high or 65 percent too low.

Continued on page 1041

Control of Chemical Processes

The seventh installment of this series presents the operation and equations for integral and derivative control actions. Integral action is used to eliminate offset; derivative action to eliminate overshoot. Each affects the quality of control and introduces phase change in the controller.

by
A. J. YOUNG

VII. Integral and Derivative Control Actions

Integral action is added to a proportional controller to eliminate offset. Integral control action is defined (B.S.I. definition 2413) as: "A type of control in which potential correction θ changes at a rate proportional to the deviation." This can be stated in equation form as:

$$d\theta/dt = -\gamma\,\theta = -\mu\,(1/S)\,(\theta) \qquad (1)$$

where γ is the integral-control factor[1], μ is the proportional-control factor, and S is the integral-action time.

The integral-control factor (which corresponds to the proportional-factor μ) is not used in practice; the setting dial for integral action on a controller is calibrated in action time, (S) (or in reciprocals of S), which is defined in terms of the proportional action. S is the time taken by the integral action to repeat the proportional action after a step change in deviation.

Fig. 7-1 shows the relation between potential correction (Θ, or regulating unit setting) and time, following a sudden disturbance, for proportional and integral control. The proportional action at once gives a potential correction (P) proportional to the deviation (θ). The integral-action correction (I) commences to increase at a rate proportional to θ and continues to increase as long as the deviation persists. It must, therefore, prevent offset.

After time S, if the deviation is held constant, $I = P$, and the total potential correction (or regulating unit movement) $= 2P$.

Fig. 7-1 has been drawn for simplicity with the offset constant at θ, in spite of the continuously increasing corrective action due to the integral action. This represents the rather unlikely case of a constantly increasing demand which the integral action corrects for in such a way as to maintain the deviation constant at θ.

$$\Theta = -\mu\,(1/S)\int_0^t \theta\,dt \qquad (2)$$

At time t after the sudden disturbance the contribution of the integral action is found by integrating equation (1), to give:

Therefore, Θ at any time t is proportional to the area between the recorded and desired value on the chart (shaded in Fig. 7-1).

Equation (2) gives rise to the term 'integral" action. It is also known widely as "reset" action, which term arises from the use of integral action to correct offset automatically instead of by "resetting" the desired value by hand.

Use of Integral Action

The usual object of adding integral action to a proportional controller is to eliminate offset. When large changes occur in plant supply or demand, there often is no alternative to the use of integral action to avoid offset. However, integral action often is used when it is not only unnecessary but also disadvantageous. Quality of control can be measured in terms of the minimum deviation-reduction factor and the time for return to desired value after a disturbance. Both of these criteria depend on the value of μ (the proportional control factor) which can be used. As μ increases, the quality of control improves, as judged by these criteria. The use of integral action decreases the permissible value of μ and therefore causes deterioration of control quality with regard to recovery after a disturbance.

The reason for this is that integral action introduces an additional phase lag into the controller. Fig. 7-2 gives the magnitude of this phase lag in terms of the ratio of operating period (T) to integral-action time (S). The curve can be verified by experiment or derived theoretically[2]. Notice that the phase lag introduced not only depends on the value of S but also increases as the plant period increases.

It is not possible to give precise guidance on the value of integral-action time (S) which should be used in various conditions, but it has been found in practice that a value of S equal to the operating period (T) is about optimum in the general case.

Effect on Quality of Control

Let us examine the effect on quality of control of using integral-action time $S = T$.

Fig. 7-2 shows that the phase lag due to integral action of this value is about 9 deg. The controller (proportional + integral) now has a total phase lag of $180 + 9 = 189$

[1] As for μ in proportional control, γ is the product of two factors (K_e, K_v) appropriate to the controller and regulating unit respectively.

[2] The phase lag due to integral action is $\tan^{-1}(T/2\pi S)$. The contribution of integral action to controller gain can be shown to be $\sqrt{1 + (T/2\pi S)^2}$, which for $T/S = 1$ is 1.01.

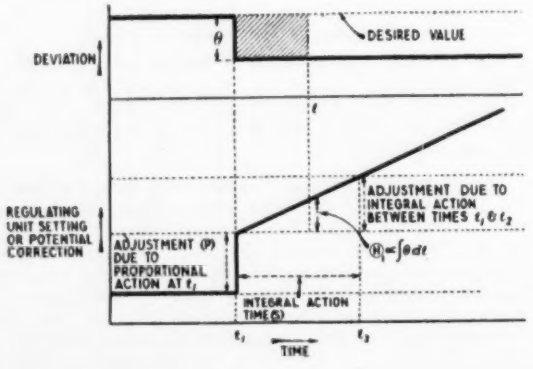


Fig. 7-1. Integral actior following a sudden and sustained change in θ, such as might be produced by a load change.

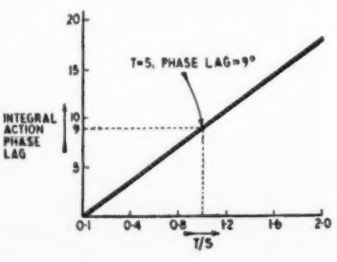


Fig. 7-2. Phase lag introduced into controller by integral action.

deg., and therefore "matches" a plant with a phase lag of $360-189 = 171$ deg., instead of 180 deg. for proportional control alone.

To decrease the plant lag from 180 to 171 deg., the operating period must be increased. This in itself implies slower recovery after a disturbance. In addition, however, the plant attenuation (A) is decreased. Therefore controller gain, which must be made equal to A, must also be decreased. Fortunately, integral action at $S = T$ makes negligible contribution to controller gain[2], but since the gain has to be reduced, μ must be decreased. The deviation-reduction factor is thus decreased and the time for return to desired value is increased.

It is, therefore, unwise to use integral action "because it is there and cannot do any harm." It can do harm; unless it is esential it should not be used without careful consideration. Much can be done by proper use of derivative action, as will be seen, to increase and decrease the proportional bandwidth; in many cases this will reduce offset to a tolerable value and make integral action unnecessary.

The seriousness of the effect of integral action on control quality depends on the extent to which operating period must be increased to obtain the required reduction in phase lag in the given plant, and how much the attenuation of the plant falls off as a consequence. These facts can be established from the frequency-response diagram of the plant.

A useful fact to remember is that integral action should be used, in general, only when the proportional band is so wide that expected load changes produce serious offset.

The shortest integral-action time (S) which can normally be used profitably is $S = T$, where T is the operating period for which the plant phase lag is 171 deg. for damped oscillations.

Equation for Proportional plus Integral Control

The output of the controller is the sum of the proportional and integral outputs, and the total potential correction Θ is the sum of the two potential corrections. Hence:

$$\Theta = -\mu\,(\theta + 1/S \int \theta\, dt) \qquad (3)$$

where the first term is the proportional-control action, and the second term is the integral-control action.

Derivative Control

It has been shown that integral action is not desirable if it can be avoided because it leads to (1) the use of a wider proportional band, (2) slower return to desired value, and (3) less control of overshoot.

A common-sense approach to the problem suggests that overshoot can be reduced by an action which is proportional to the *rate of change of the deviation*. In this way a rapid departure from the desired value would be countered by a large corrective action, which would be brought into play as soon as the change commenced, and which would be reduced as the rate of change became less.

Such an action is available in proprietary makes of controller. It is called *derivative action*. Derivative control is defined (B.S.I. Definition 2414) as: "A type of control in which the potential correction is proportional to the rate at which the deviation changes." This definition can be stated in the equation:

$$\Theta = -\rho\, d\theta / dt = -\mu\,(R)\, d\theta/dt \qquad (4)$$

where ρ is the derivative-control factor, and R is the derivative-action time.

As for proportional and integral control actions, the derivative-control factor (ρ) is determined by the product K_2K_c, where K_2 is the derivative-action effect due to the controller, and K_c is the valve coefficient (assumed linear for small displacements. That is,

$$\rho = K_2K_c$$

The controller output due to derivative action is

$$V_D = -K_2\, d\theta/dt$$

Therefore $\Theta = K_cV_D = -K_cK_2\, d\theta/dt = -\rho d\theta/dt$

The derivative-control factor is not used in practice. As for integral control, the magnitude of derivative action is defined as a time (R) in terms of the proportional action of the controller. The *derivative action time* (R) is defined (B.S.I. definition 2504) as: "The time interval in which the proportional action increases by an amount equal to the derivative action when the deviation is changing at a constant rate."

Fig. 7-3 shows the effect of derivative action. Note that the full derivative action corresponding to any rate of change of θ, takes place immediately θ commences to change at this rate, and remains constant as long as the *rate of change* of θ remains constant.

As for integral action, the addition of derivative action to a proportional controller introduces a phase change. Integral action, we have seen, produces a phase *lag*, with consequent disadvantages; derivative action produces a phase *advance*, and from this derives its great value[3]. This phase advance depends on the derivative-action time and on the operating period. Phase advance is plotted against T/R in Fig. 7-4.

Derivative Action as a Means for Increasing μ

Quality of control improves as μ is increased. When proportional control is used alone, the value of μ is fixed by the attenuation in the plant at the natural period which gives 180 deg. phase lag. As the addition of integral action increases the controller phase-lag, a proportional + integral action controller must be matched to the plant at a longer period, which gives less phase lag. At this period the attenuation will be less and hence the value of μ will have to be less.

In order to be able to use an increased value of μ, it is necessary to work at a shorter period, for which the plant attenuation is greater. At this period there is also greater phase lag in the plant. The controller must therefore produce correspondingly less phase difference at this period.

Unfortunately, derivative action makes a considerable contribution to controller gain[3], as can be seen from Fig.

[3] Phase advance due to derivative action is $\tan^{-1}(2\pi R/T)$, where R is the derivative-action time, and T is the operating period. The additional gain produced by derivative action is given by the factor $\sqrt{1 + (2\pi R/T)^2}$.

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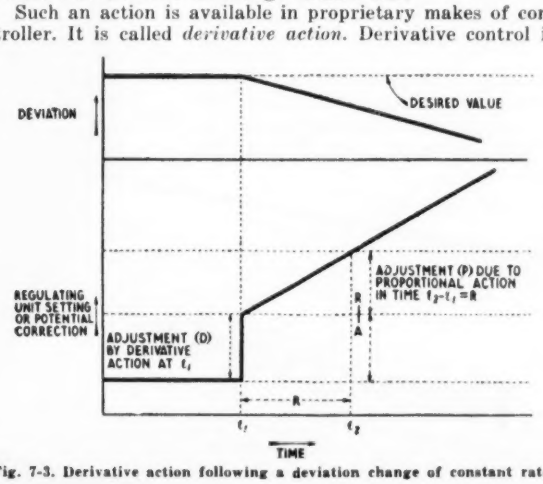

Fig. 7-3. Derivative action following a deviation change of constant rate.

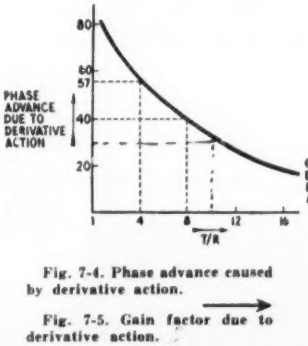

Fig. 7-4. Phase advance caused by derivative action.

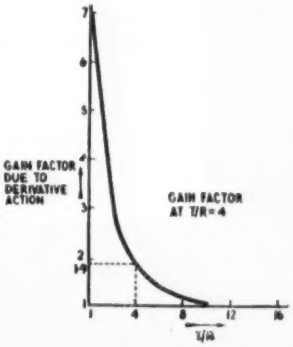

Fig. 7-5. Gain factor due to derivative action.

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Last Tuesday, Meeting at 7:30 P. M., Orange County Courthouse, Orange, Texas.

SARNIA
L. J. Hall, 730 Talfourd St., Sarnia, Ont., Canada. Tel: EDgewater 2258.
Third Monday, 8:00 P.M., Y.M.—Y.W.C.A.

SAVANNAH RIVER
F. P. Ledford, Jr., 907 Royalette St. N. Augusta, S. C., Tel: 5-4626
Second Wednesday, Dinner at 7:30 P.M. North Augusta Legion Post.

SEATTLE
Frank S. Melder, 2439 76th N.E. Bellevue, Washington, Second Friday.

SOUTH TEXAS
Homer C. Givens, P.O. Box 637, Falfurrias, Texas. Tel: 202
First Thursday, Engineers Club

ST. LOUIS
W. G. Lee, 4710 Delor St., St. Louis 16, Mo. Tel: FL 8516.
First Wednesday After First Monday, Meeting at 8:00 P. M.

TOLEDO
Howard R. Daily, 2025 Scottwood Ave., Toledo, Ohio.
Third Tuesday, Meeting at 8.00 P. M.

TORONTO
John W. Huether, 311 Sutherland Dr., Leaside, Ontario, Canada. Tel: HU-7114
Fourth Thursday, Meeting at 8:00 P. M.

TULLAHOMA
B. A. Artz, RFD #2, Tullahoma, Tenn.

TULSA
A. J. Sesock, 845 South East Ave., Tulsa, Okla., Tel: 8-1112
First Monday, Meeting at 7:30 P.M.

TWIN CITIES
John L. Schmidt, 1879 University Ave., St. Paul 4, Minn., Tel: DR 0064
Fourth Tuesday, Dinner at 6:30 P.M., Meeting 7:30 P. M.

WASHINGTON
Edward C. Lloyd, 2105 Spencer Road, Silver Spring, Md. Tel: SH. 9340.
Third Monday, Meeting at 8:00 P. M.

WAYNE COUNTY
Clarence Ellison, 2443 15th St., Wyandotte, Michigan. Tel: Avenue 2-4178.
Third Monday, Meeting at 8:00 P. M.

WICHITA
321 W. Douglas Ave., Wichita 2, Kansas
J. W. Rieg, c/o Koch Engineering Co., Inc., Third Thursday, 8 P. M. Scientific Bldg.

WILMINGTON
W. C. Ruglass, 900 A West 8th Street, Wilmington, Delaware
Second Tuesday, 8:00 P. M. Harlan School.

Tennessee Section Changes Name

At the Executive Board meeting held in Chicago June 10-11th the petition for a change of name from the Tennessee Section was approved. Hereafter, this Section will be known as Northeast Tennessee Section.

Two Sections Added

Two new Sections have been added to the ever growing ISA. Tullahoma Section, located in Tullahoma, Tennessee has submitted the names of 26 charter members.

The charter for the Milwaukee Section was approved by the Executive Board. This brings the total of ISA Sections to 75.

ISA NEWS

The rapid and continued growth of the ISA in membership has been paralleled by an equal growth in ISA activities. This growth has led to periodic adjustments of the numbers and duties of the members of the Executive Board. Much of the work which the Secretary's Office covered in the early days is now assigned either to the Society Manager or to the Exhibit Manager or to one of the four Vice-Presidents, or to various special committees. This situation is perhaps fortunate, in that it relieves the Secretary of much detail, and permits more concentration on the businesslike conduct of Society business and on helping to define problems for board action.

W. A. WILDHACK

One goal toward which the Secretary and the Board are trying to work is to have all items for board action adequately summarized in advance of board meetings so that board members may start their deliberations on the basis of well considered opinions. The background for board action should normally be studies or recommendations made or reviewed by appropriate ISA committees or officers. Another goal is to have complete and understandable reports on board actions for the information of ISA sections and council delegates. In this connection, comments, criticisms, and suggestions from delegates will be most helpful. (Minutes of the Board meeting held in Chicago June 10 and 11 were prepared with the help of the Society Manager and sent to section delegates within a few weeks).

The Secretary is also drawn into new activities which the Society must continually study to determine in what way the basic objectives of the Society can best be realized. In this connection, the Secretary has been involved with Technical Vice-President Brand in the ISA co-sponsorship of the *National Telemetering Conference* (jointly with the American Institute of Electrical Engineers, the Institute of Radio Engineers and the Institute of the Aeronautical Sciences). This cooperative conference was technically of high quality, financially operated on a break-even basis, and the ISA will join with the other Societies in sponsoring another Telemetering symposium next year. A similar cooperative sponsorship will be extended to a conference on *Instrumentation and Nucleonics in Medicine* to be held in October in New York City.

In each of these cooperative ventures, the ISA merely joined in an activity already underway. Important questions now under study by the Board are:

To what extent should the ISA join in such instrumentation activities initiated by other groups? and

To what extent should the ISA (Nationally or locally) take the initiative in sponsoring or co-sponsoring local, regional, or additional National Conferences and Exhibits?

Thoughtful advice (and active participation) of members, delegates, and officers, will be required to formulate and carry out the program of activities whereby the Society can most effectively advance the art and science of instrumentation.

W. A. Wildhack, Secretary

Plans Set for Maintenance Clinic

George A. Larsen, Chairman of the Maintenance and Operation Committee announces that plans have been completed for the Fifth Preconference ISA Instrument Maintenace Clinic which will offer to instrument men and apprentices instruction on maintenance of various basic types of instruments.

The Clinic will begin on Friday, September 18th at 1:00 PM. There will be a total of nine two-hour sessions; three each on Friday, Saturday, and Sunday. Friday evening will be devoted to a general session on "Principles of Instrumentation and Automatic Control".

The sessions will be held in the various classrooms set up in the Morrison Hotel.

This Clinic is open to members of the Instrument Society of America and members of Co-operating Societies without charge. Non-members may attend to the extent of available space after registration of members. Non-members will be charged a $3.00 registration fee which must accompany application. Prior registration is required by those desiring to attend this Clinic. Registration will close September 14.

Assignment of students to classes will take place on Friday morning September 18th in the main lobby of the Morrison Hotel.

The popular sound and color film "Principles of Automatic Control" will be shown continuously from 9:00 AM to 12:00 noon on Friday during the registration period.

Actual hours of the Clinic are: Friday; 1:00—3:00 PM, 3:15—5:15 PM, Saturday; 8:00—10:00 AM, 1:00—3:00 PM, 3:15—5:15 PM, Sunday; 9:30—11:30 AM, 1:00—3:00 PM, 3:15—5:15 PM.

Enough instructors are being provided by instrument manufacturers to take care of about 400 students. Every effort is being made to keep classes as small as possible within the limit of available facilities. Students will be assigned to a class group which will progress from one classroom to another until the eight subjects of their schedule have been covered; these, supplemented by the general session on Friday evening, will complete the course.

A certificate will be given to students who attend all regular class sessions.

CLINIC PROGRAM

The Clinic will run three simultaneous schedules designated as A, B, and C.

SCHEDULE A	INSTRUCTOR
Pyrometers, Millivoltmeter Type	Barber-Colman Co.
Mechanical and Electronic Potentiometers	Leeds & Northrup Co.
Electronic Potentiometers	Minneapolis-Honeywell
Graphic Panel Instruments	Moore Products Co.
Control Valve Selection & Maintenance	Fisher Governor Co.
Flow Meters (Elec. Type)	Republic Flow Meter Co.
Combustion Control	Hays Corporation
Electric Instruments	Esterline Angus Co.
SCHEDULE B	
Electronic Potentiometers	The Bristol Co.
Graphic Panel Instruments	Minneapolis-Honeywell
Control Valve Selection & Maintenance	Keiley-Mueller Co.
Pressure Pilots and Air Relays	Black, Sivalls & Bryson
Graphic Panel Instruments	Taylor Instrument Co.'s
Liquid Level Control	Fisher Governor Co.
Flow Meters (Electric Type)	Republic Flow Meter Co.
Combustion Control	Hagan Corporation
Oxygen Recorder	Hays Corporation
SCHEDULE C	
Pyrometers Millivoltmeter	Barber-Colman Co.
Thermocouples and Lead Wire	C. G. Gordon Company
Electrical Instruments	Weston Electric Instrument Co.
Graphic Panel Instruments	The Foxboro Co.
Control Valves	Mason-Nielan Company
Area Type Flow Meters (Rotameter)	Fisher & Porter Co.
Combustion Control	Bailey Meter Co.
Self Operated Controls	Leslie Regulator Co.

When registering the student should designate first and second choice. The committee reserves the right to assign late registrants to another schedule if necessary to keep the program balanced.

Hotel reservations should be made by students directly with the hotels and as far in advance as possible.

Registration for the Clinic can be made by writing to George Larsen, 612 Eleventh Street, Lockport, Illinois. Please write plainly giving name, company, schedule preferences, and include $3.00 if not an ISA member. This fee can be applied to ISA membership.

Dynamic Behavior of Pneumatic Devices

by L. A. GOULD and P. E. SMITH, JR.

(Continued from last month)

The transfer function relating $\frac{A_p}{A_R} P_o + \frac{A_d}{A_R} P_d - P_R$ to P_o is given by:

$$\frac{\frac{A_p}{A_R} P_o + \frac{A_d}{A_R} P_d - P_R}{P_o} = \frac{aT_dT_Rs^2 + [T_R + a(1+c)\,T_d]s}{T_dT_Rs^2 + [T_R + (1+c)\,T_d]s + 1} \quad (14)$$

where $T_d = R_dC_d$

$T_R = R_RC_R$

and $c = C_R/C_d$

$a = A_p/A_R$

Thus the block diagram of the three-action controller is as shown in Fig. 18.

By reducing the diagram of Fig. 18, the response of the three-action controller to a change in X_s is found to be:

$$\frac{P_o(s)}{X_e(s)} = k_{nr}(1-K_1)\frac{T_dT_Rs^2 + [T_R + T_d(1+c)]s + 1}{T_dT_R(1+aK_l)s^2 + [T_R(1+K_l) + T_d(1+c)(1+aK_l)]s + 1} \quad (15)$$

where $K_l = K_1k_{nr}K_{fb}$ = loop sensitivity.

In the controller tested, $c = 2$ and $a = 1/5$. The response (15) then becomes:

$$\frac{P_o(s)}{X_e(s)} = k_{nr}(1-K_1)\frac{T_dT_Rs^2 + (T_R + 3T_d)s + 1}{T_dT_R\left(1+\frac{K_l}{5}\right)s^2 + \left[T_R(1+K_l) + 3T_d\left(1+\frac{K_l}{5}\right)\right]s + 1} \quad (16)$$

Factoring Equation 16 leads to

$$\frac{P_o(s)}{X_e(s)} = k_{nr}(1-K_1)\frac{(T_xs+1)\quad(T_zs+1)}{(\alpha_xT_xs+1)\left(\frac{T_z}{\alpha_z}s+1\right)} \quad (17)$$

with $\alpha_x > 1$ and $\alpha_z > 1$, and $T_x > T_z$. These quantities are expressed in Appendix II.

The response Equation 17 is plotted in Fig. 19 for a notch ratio of 10 with different proportional band settings (for assumed values of $k_{nr} = 1.25 \times 10^4$ and $K_{fb} = 6 \times 10^{-3}$). The notch ratio is defined as T_x/T_z and, for the values chosen for c and a, has a minimum value of 9.9. This ratio is a function only of T_d/T_R.

Conclusion

A theoretical analysis of typical pneumatic circuits has been developed. The technique used may be extended to other types of circuits. The results of the analysis demonstrate in a concise manner the nature of the controller response function as dial settings are varied.

Pneumatic Amplifiers

In the first part of this paper pneumatic controllers are analyzed on the basis of ideal amplifier response. In practice, the responses of the amplifiers in the controller loop are characterized by dynamic lags. In many applications these lags may be so small compared to the lags in the plant being controlled that they can be neglected.

On the other hand, as attempts are made to control faster and faster processes by means of pneumatic controllers, the limitations imposed by the lags in the controller itself become important. The presence of the lags in the amplifiers which are part of the controller alters the controller response from the desired ideal.

In order to design fast pneumatic amplifiers, it is necessary to know the parameters of the amplifiers which contribute to the dynamic response. Then, by proper choice of the parameters, the response can be improved so as to maintain ideal controller action.

In this section, the nozzle-flapper and a typical pilot relay are analyzed to demonstrate the various parameters which may enter into the dynamic lag of each device.

Nozzle-Flapper Amplifier

A schematic diagram of the nozzle-flapper amplifier is shown in Fig. 20. The operation is such that moving the flapper toward the nozzle increases the back pressure, P_o, and moving the flapper away from the nozzle decreases the back pressure. The load volume represents the capacity of a valve motor or the input capacity of a pilot relay or a booster amplifier.

The equivalent pneumatic circuit of the nozzle-flapper is shown in Fig. 21.

In Fig. 21 the following quantities are used:

P_s—supply pressure

P_o—output pressure (back pressure of nozzle)

R_s—resistance of supply restriction

C_L—capacity of load volume

R_n—equivalent resistance of nozzle

A theoretical analysis of the performance of the amplifier can be derived in the following manner. Assume that the flow through the nozzle is proportional to the output pressure divided by the nozzle resistance, and that the nozzle resistance is linearly related to the flapper position. Then the nozzle flow is given by:

$$F_n = \frac{k_1P}{R_n} = \frac{k_1P_o}{k_2X_f} = \frac{k_nP_o}{X_f} \quad (18)$$

where k_1, k_2, and k_n are proportionality constants. If the variation of the flapper position consists of small motions about an average value, then:

$$x_f = X_{fo} + x_{fl} \quad (19)$$

where X_{fo} = average flapper position

x_{fl} = variation of flapper position about its mean

Similarly, $P_o = P_{oo} + p_{ol}$ (20)

$F_n = F_{no} + f_{nl}$ (21)

where P_{oo} = average output pressure

p_{ol} = variation of output pressure

F_{no} = average nozzle flow

f_{nl} = variation of nozzle flow

For small motions, the variations are small compared to the average values. Then:

$$\frac{1}{x_f} = \frac{1}{X_{fo}+x_{fl}} \simeq \frac{1}{X_{fo}} - \frac{x_{fl}}{X_{fo}^2} \quad (22)$$

Thus the equation for nozzle flow becomes:

$$F_{no}+f_{nl} = \frac{k_n}{X_{fo}}\left[P_{oo} - \frac{P_{oo}}{X_{fo}}x_{fl} + p_{ol}\right] \quad (23)$$

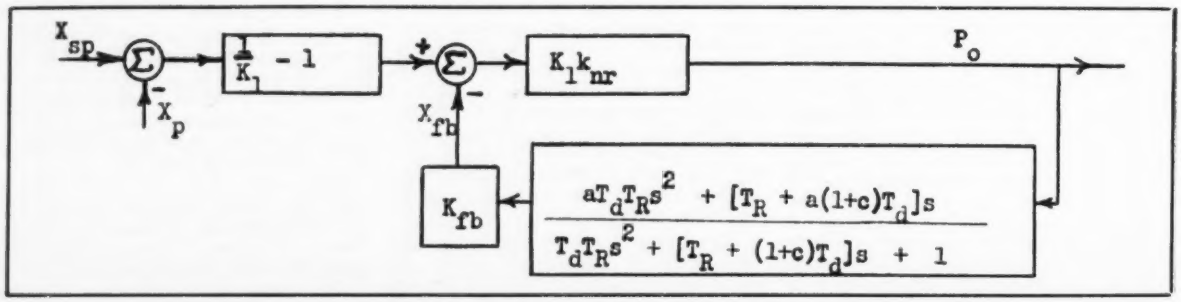

Fig. 18 Block diagram of a three-action controller.

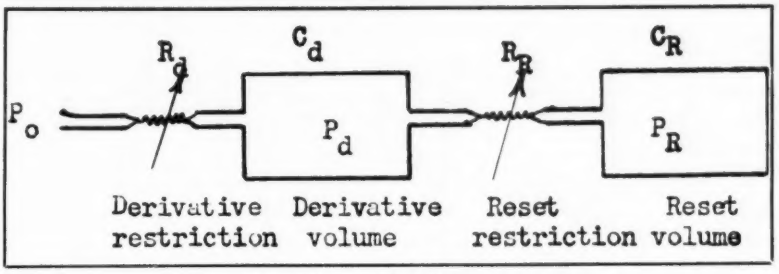

Fig. 17 Feedback network for a three-action controller.

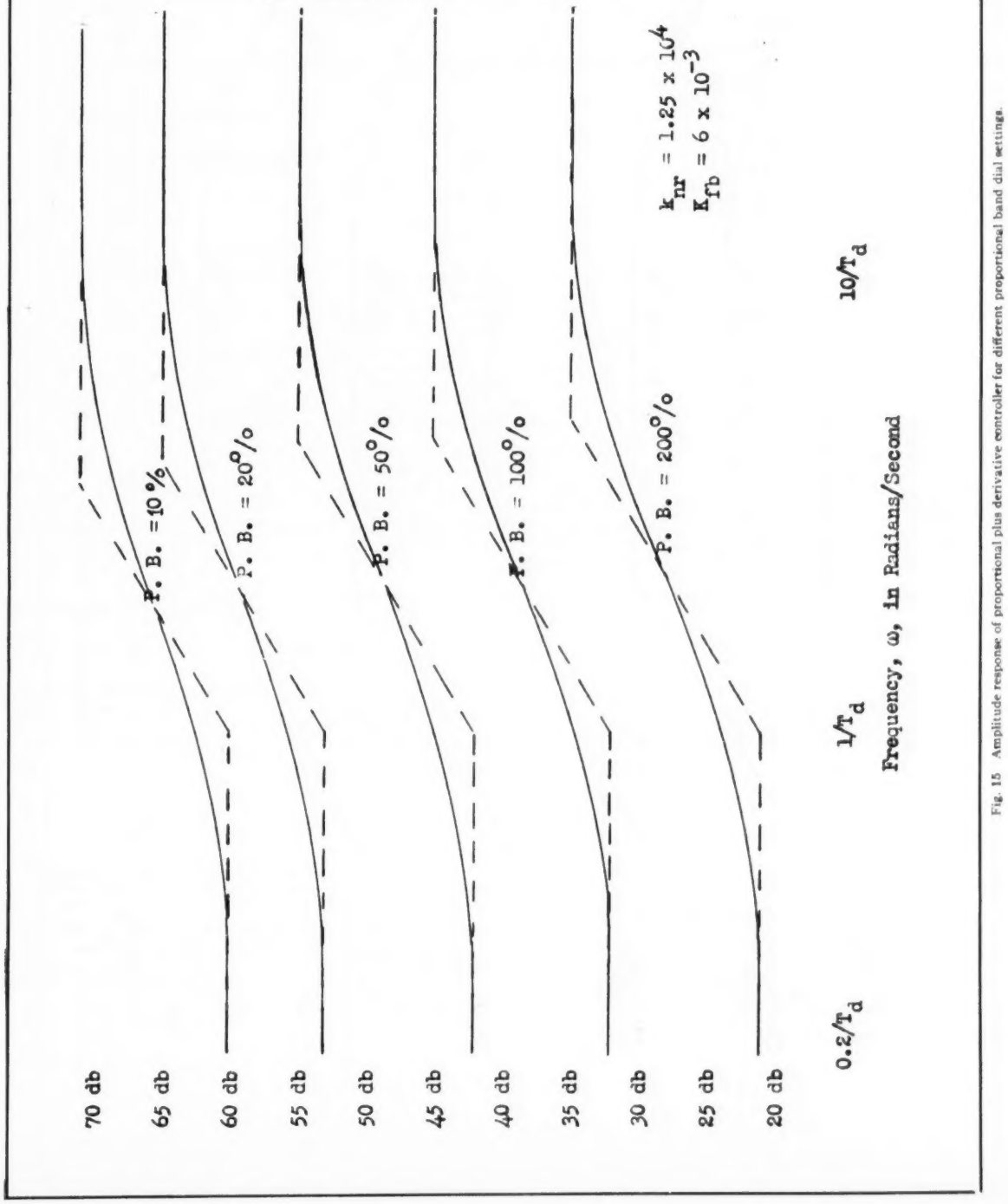

Fig. 15 Amplitude response of proportional plus derivative controller for different proportional band dial settings.

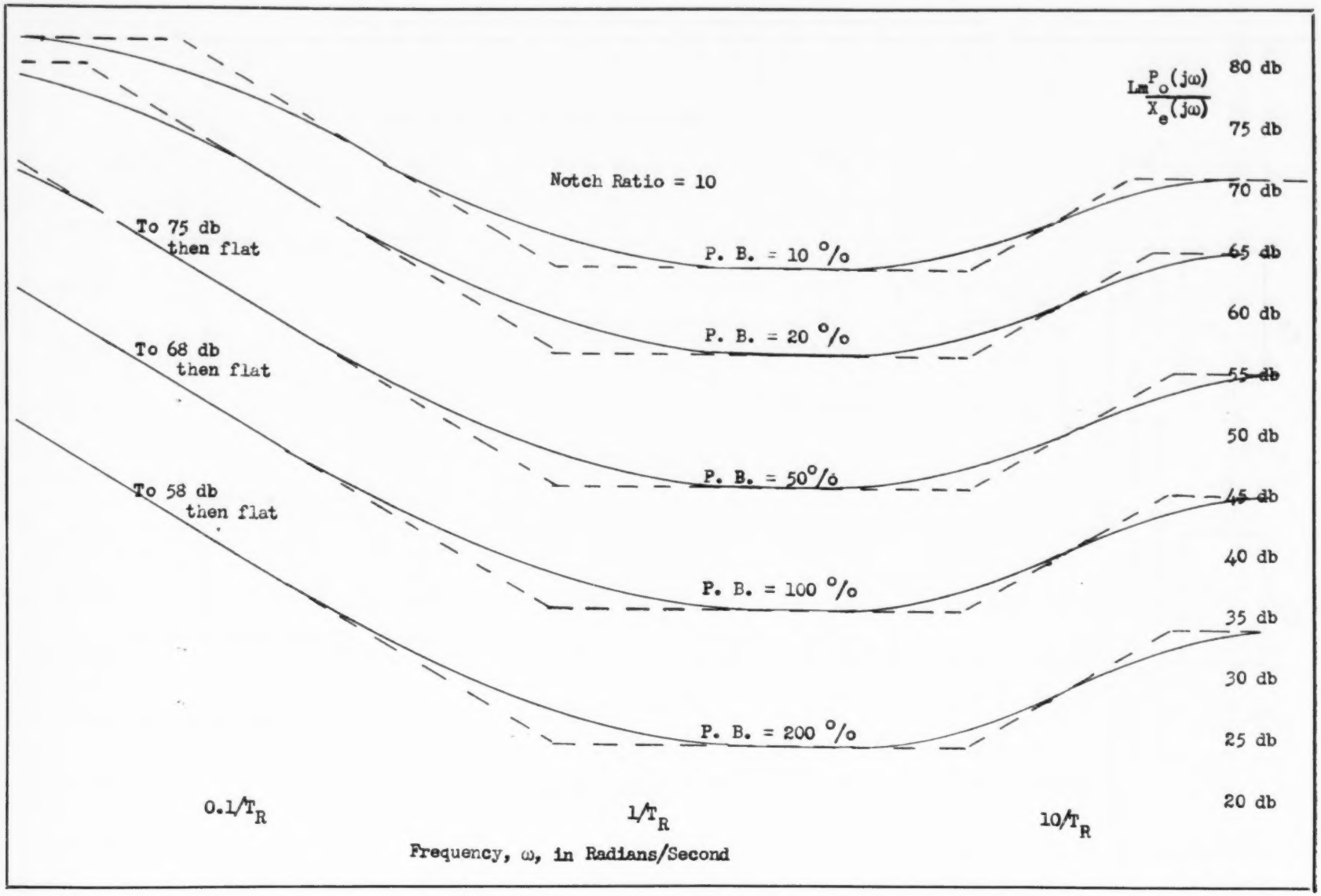

Fig. 19 Response of three-action controller for different settings (notch ratio = 10).

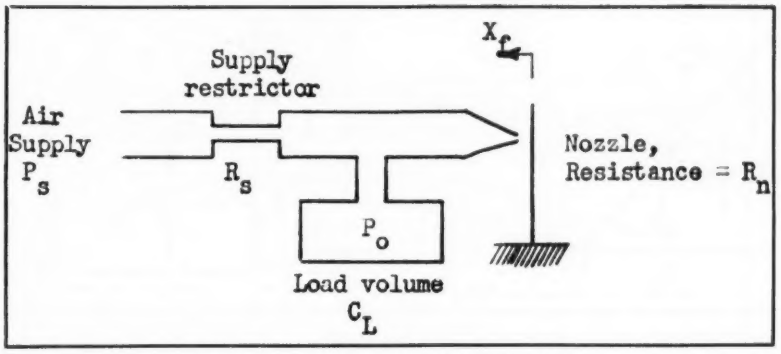

Fig. 20 Schematic diagram of nozzle-flapper amplifier.

if higher order terms involving the small variations are neglected.

If the system is at rest at its mean position, the average nozzle flow is given by:

$$F_{no} = \frac{k_n P_{oo}}{X_{fo}} \tag{24}$$

Subtracting Equation *24* from *23* yields the equation relating the variations:

$$f_{nl} = \frac{k_n}{X_{fo}}\left[p_{ol} - \frac{P_{oo}}{X_{fo}} x_{fl}\right] \tag{25}$$

The other equations necessary to determine the response of the amplifier are based on linear circuit theory. The supply flow is equal to the sum of the flows through the nozzle and into the load volume, i.e.,

$$F_s = F_c + F_n \tag{26}$$

where F_s = supply flow

F_c = flow into load volume

The flow into the load volume is given by

$$F_c = C_L \frac{d P_o}{d t} \tag{27}$$

and the supply flow is given by

$$F_s = \frac{P_s - P_o}{R_s} \tag{28}$$

Subtracting the mean values from Equations *26*, *27* and *28* gives:

$$f_{sl} = f_{cl} + f_{nl} \tag{29}$$

$$f_{cl} = C_L \frac{d\, p_{ol}}{dt} \tag{30}$$

$$f_{sl} = -\frac{p_{ol}}{R_s} \tag{31}$$

The Equations *25*, *29*, *30* and *31* can be represented by a block diagram as shown in Fig. 22.

By reducing the block diagram of Fig. 22, the response of the nozzle-flapper amplifier is given by:

$$\frac{P_o(s)}{x_{fl}(s)} = \frac{k_{nr}}{T_n s + 1} \tag{32}$$

where

$$k_{nr} = \frac{F_{no}}{X_{fo}} \cdot \frac{R_{no} R_s}{R_{no} + R_s} \tag{33}$$

$$T_n = \frac{R_{no} + R_s}{R_{no} R_s} \cdot C_L \tag{34}$$

and $R_{no} = X_{fo}/k_{nr}$ = average nozzle resistance.

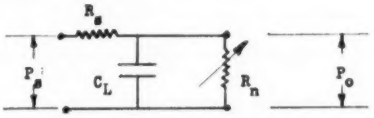

Fig. 21 Equivalent circuit of a nozzle-flapper amplifier.

From Equations *32* and *34* it is seen that the time constant of the nozzle-flapper amplifier, T_{nr}, can be reduced to improve the speed of response by reducing the loading capacity, C_L, or by reducing either the supply resistance or the average nozzle resistance. In practice, requirements of pressure and flow at the output preclude changes in resistance values.

However, the loading capacity can be reduced by avoiding large volumes at the output of the amplifier. This is accomplished in an on-off system by using a booster relay between the nozzle-flapper amplifier and the valve. In a continuous controller, the nozzle-flapper amplifier is followed by a pilot relay which has a small input volume.

Pilot Relay

For the controller tested, the pilot relay is as shown in Fig. 23.
In Fig. 23,

P_o = relay output pressure

P_s = supply pressure

The equivalent pneumatic circuit of the pilot relay is shown in Fig. 24.

x = opening of the ball valve

y = opening of the cone valve

G_c = conductance of the cone valve

G_b = conductance of the ball valve (reciprocal of ball valve resistance)

X_m = maximum opening of x

Y_m = maximum opening of y

It is assumed that a linear relationship holds between conductance and displacement, in particular that:

$$G_b = K_b (X_o + x) \tag{35}$$

$$G_c = K_c (Y_o + y) \tag{36}$$

From the definitions shown in Fig. 24 there results

$$Y_o = X_m - X_o \tag{37}$$

$$y = -x \tag{38}$$

Substitution into Equation *36* leads to

$$G_c = K_c (X_m - X_o - x) \tag{39}$$

The flow is taken as the product of pressure and conductance, thus

$$F_b = G_b P_b = K_b (X_o + x)(P_{bo} + p_b) \tag{40a}$$

$$F_c = G_c P_o = K_c (X_m - X_o - x)(P_{oo} + p_o) \tag{40b}$$

where

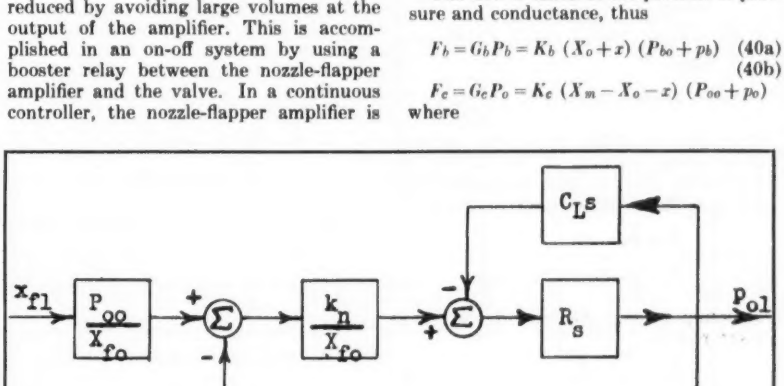

Fig. 22 Block diagram of nozzle-flapper amplifier.

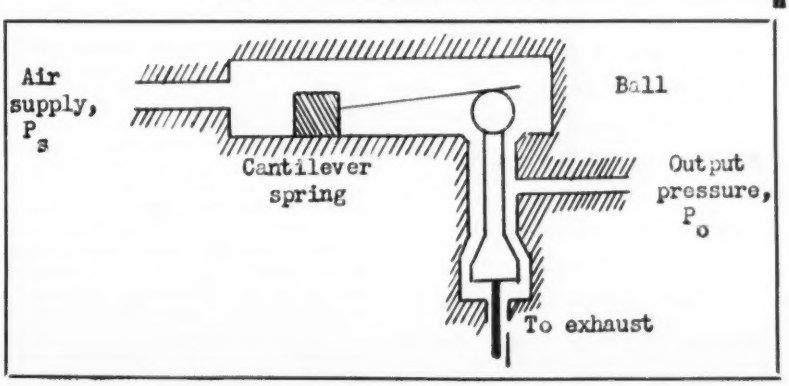

Fig. 23 Schematic diagram of pilot relay.

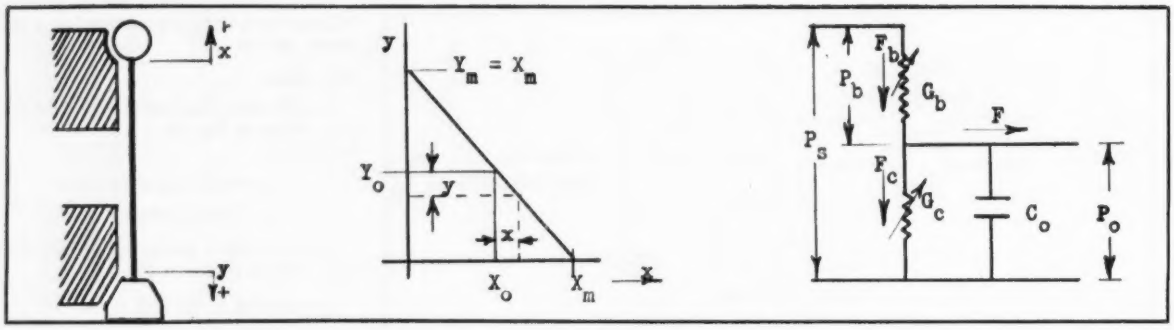

Fig. 24 Defining relationships and equivalent circuit for the pilot relay.

X_o is average opening of ball valve

x is the deviation from the average opening

Y_o is the average opening of the cone valve

y is the deviation from the average opening

P_{oo} is the average output pressure

p_o is the deviation from the average pressure

P_{bo} is the average pressure drop across the ball valve

p_b is the deviation from the average

X_m is the maximum opening of the ball valve

Y_m is the maximum opening of the cone valve

(other symbols defined in Fig. 24.)

Note that P_s is the sum of the pressure drops across output, P_o, and across the ball valve, P_b. This leads to the following result, with definitions as given above:

$$P_b + P_o = P_s \tag{41}$$

$$P_s = P_{bo} + p_b + P_{oo} + p_o$$

Equating average values and deviations there results:

$$P_s = P_{bo} + P_{oo} \tag{42}$$

and $$p_b = -p_o \tag{43}$$

Expanding Equation *40a* and *40b* leads to the result (neglecting products of deviations):

$$F_b = K_b X_o P_{bo} + K_b P_{bo} x + K_b X_o p_b \tag{44a}$$

$$F_e = K_e (X_m - X_o) P_{oo} + \tag{44b}$$

$$K_e (X_m - X_o) p_o - K_e P_{oo} x$$

and, since $F = F_b - F_e$ it is seen that

(45)

$$F = [K_b X_o P_{bo} - K_{c_o}'' (X_m - X_o) P_{oo}] +$$

$$[K_b P_{bo} + K_e P_{oo}] x +$$

$$[K_b X_o - K_{c_o}'' (X_m - X_o)] p_o = F_o + f$$

Generally the average value of F will be zero. Therefore, from Equation *45*:

$$K_b X_o P_{bo} = K_e (X_m - X_o) P_{oo} \tag{46}$$

Further simplification leads to the relationship:

$$P_{oo} = \frac{P_s K_b X_o}{K_b X_o + K_e X_m - K_e X_o} \tag{47}$$

This can represent a straight line relation between average pressure and average displacement if $K_b = K_e$. For other adjustments a convex or concave curve can be achieved. It might be possible to match the relay characteristics to the nozzle-flapper characteristic so as to achieve an over-all linear result by using $K_b = K_e$. For this case,

$$P_{oo} = \frac{P_s}{X_m} X_o \tag{48}$$

It is possible to determine the flow, f, if the load which is at pressure P_o is known. In the simplest case the load can be taken as purely capacitative.
In this case,

$$f = C \frac{dp_o}{dt} \tag{49}$$

But, from Equation *45*

$$f = [K_b P_{bo} + K_e P_{oo}] x + \tag{50}$$

$$[K_b X_o - K_e (X_m - X_o)] P_o$$

Equating *49* and *50* and remembering that $K_b = K_e$, there results

$$C \frac{dp_o}{dt} + K_e X_m p_o = K_e P_s x \tag{51}$$

The transfer function for the relay amplifier is found from Equation *51* to be:

$$\frac{p_o(s)}{x(s)} = \frac{P_s / X_m}{T_r s + 1} \tag{52}$$

where:

$$T_r = C / K_e X_m = C / G_m = C R_{min}$$

and R_{min} = minimum resistance of ball or cone valve (assumed equal when $K_b = K_e$)

The same remarks made about the speed of response of the nozzle-flapper amplifier hold for the pilot relay. In general, the restrictions on loading capacity for the pilot relay are much more severe (than for the nozzle-flapper) since the relay is used to drive diaphragm valves which generally have sizable capacities. If a pneumatic line is the load of the relay, the foregoing analysis does not hold since the load can no longer be represented by a lumped capacity. This case (pneumatic transmission line loading the pilot relay) can be analyzed by techniques similar to those used above, but the analysis is more involved.

Non-Ideal Proportional Controller

In the previous section, the response of the ideal proportional controller was found to be a static sensitivity which was a function of proportional band only. There was no dynamic lag evident. If the dynamic characteristics of the nozzle-flapper and the pilot relay are taken into account, the actual response of the proportional controller is characterized by a second-order lag which is dependent upon the setting of the proportional band as well as upon the loading of the pilot relay.

The block diagram of the non-ideal proportional controller is shown in Fig. 25.

By reducing the block diagram of Fig. 25 the response of the non-ideal proportional controller is found to be:

$$\frac{P_o(s)}{X_c(s)} = \frac{(1 - K_1)\, k_{nf}\, k_{pr}}{1 + K_L} \tag{53}$$

$$\frac{1}{\left(\frac{s}{\omega_n}\right)^2 + 2\mathfrak{I} \frac{s}{\omega_n} + 1}$$

where:

$$K_L = K_1 K_{fb} k_{nf} k_{pr}$$

and $$= \mathfrak{I} \frac{T_n + T_r}{2 \sqrt{T_n T_r}\ \sqrt{1 + K_L}}$$

and $$\omega_n = \frac{1 + K_L}{\sqrt{T_n T_r}}$$

Values of $\mathfrak{I}$ and ω_n have been calculated based on measured values of K_L, T_n, and T_r. These results are presented in the following section.

Experimental Measurements

A limited experimental investigation of the controller discussed has been carried out. The investigation has not been thorough and serves only as an indication of the validity of the method discussed above.

Two types of experimental investigation were used, namely: frequency response testing and transient (step) testing. The controller was tested as a proportional controller with various settings of the proportional hand dial. The test signal was a sinusoidal motion of the error linkage with the controller connected as shown in Fig. 26.

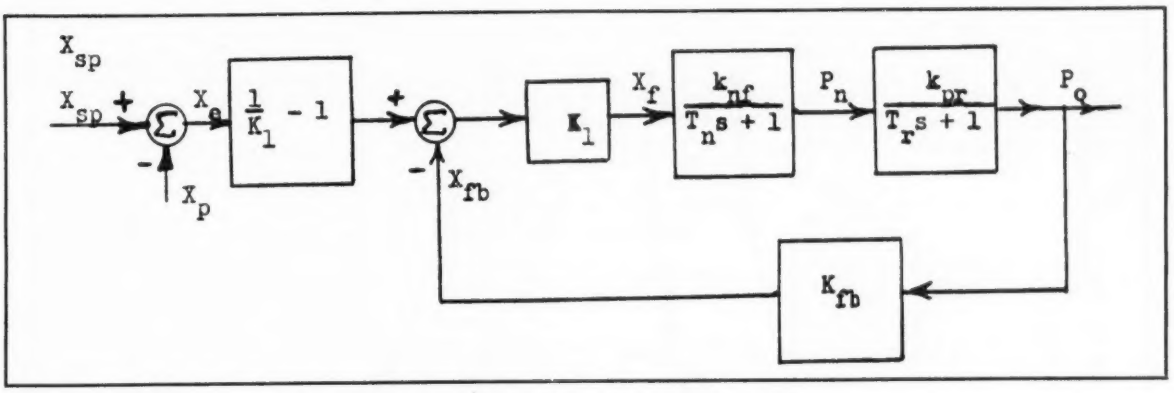

Fig. 25 Block diagram of non-ideal proportional controller.

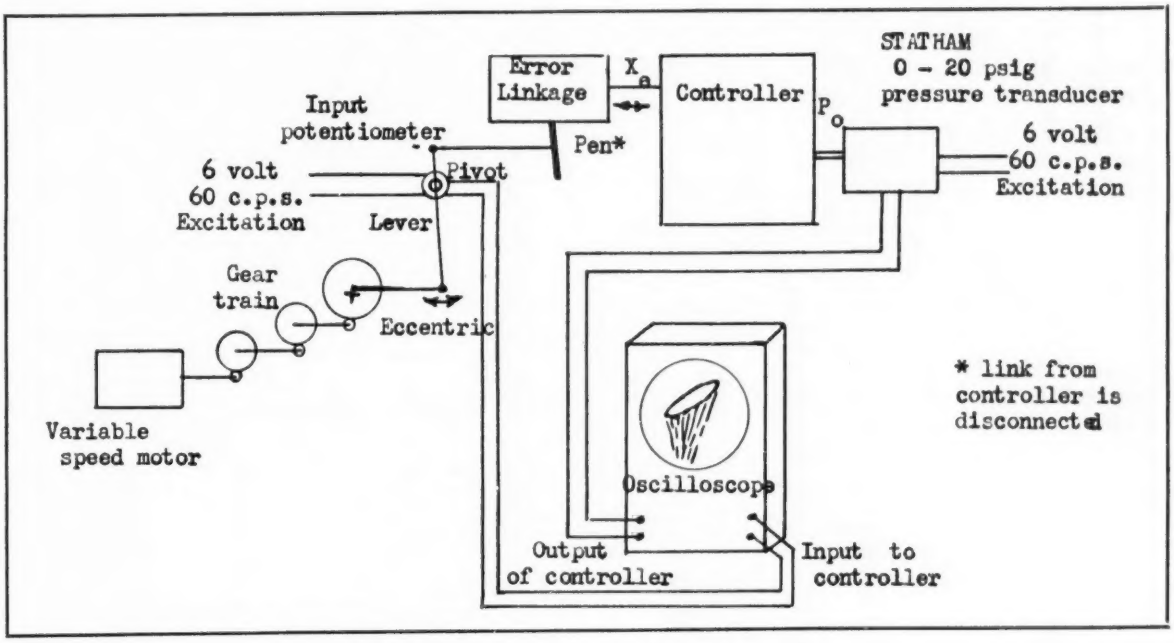

Fig. 26 Schematic diagram of test set-up for pneumatic controller.

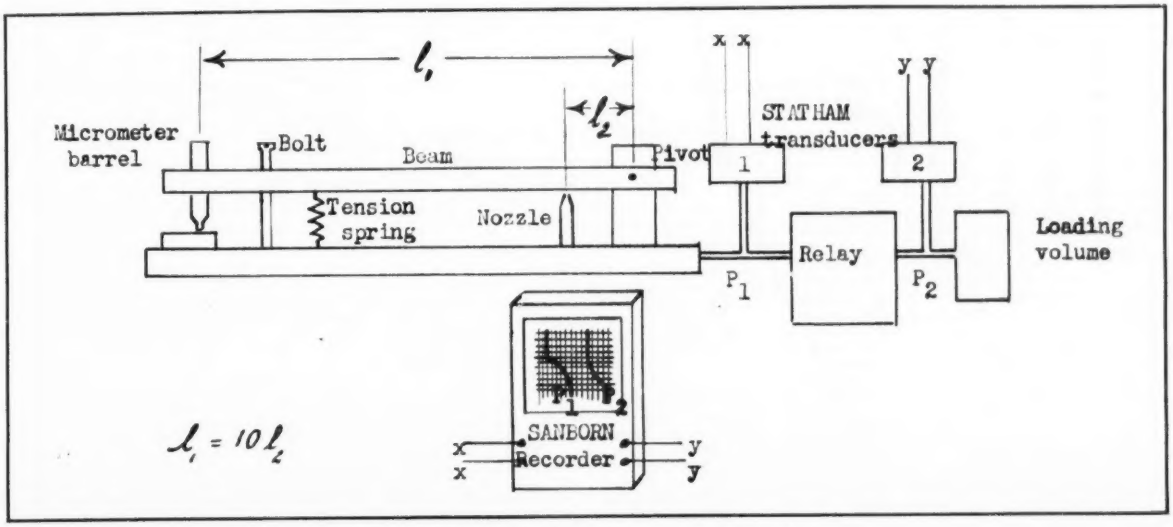

Fig. 27 Schematic diagram of test set-up for pneumatic amplifiers.

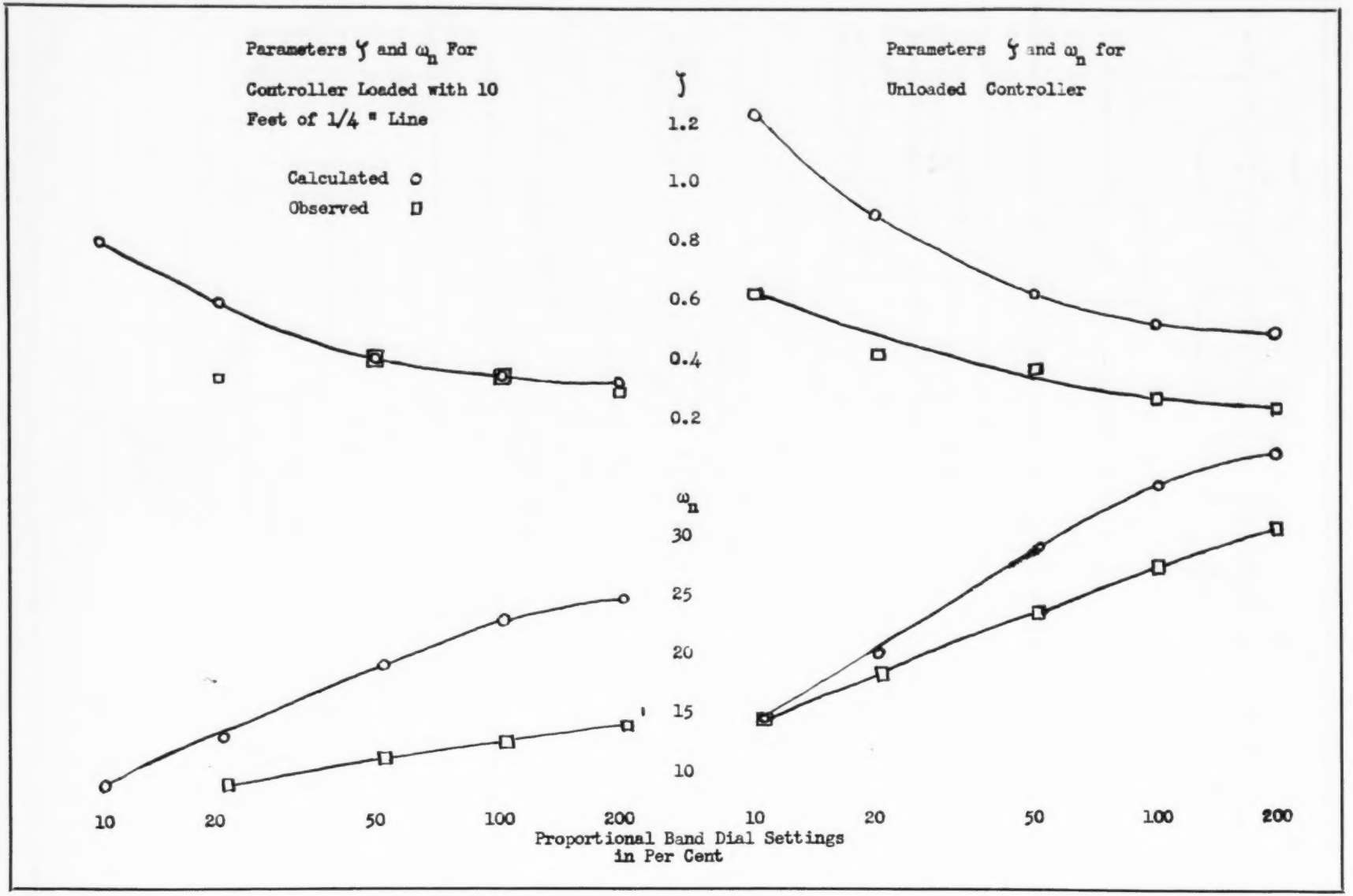

Fig. 28 Comparison of observed and calculated values.

The two component amplifiers (the nozzle-flapper and the relay) were tested by applying a step displacement to the flapper and measuring nozzle back pressure and relay output pressure as functions of time. The apparatus used is shown in Fig. 27.

The values of time constants derived for the amplifiers varied widely. The variation is due to three causes, namely: experimental errors; graphical errors incurred in obtaining time constants from curves; and the fundamental variation due to the non-linear nature of the system. Two principal sources of non-linear action are the non-linear proportional gain of the amplifiers and the dependence of the pneumatic capacity on average pressure.

These non-linearities are not necessarily disadvantageous, but they do lead to the necessity for a more thorough investigation if better correlation between predicted and observed results is to be achieved. The average values of time constants were found to be 1.8 seconds for the nozzle-flapper and 0.4 second for the relay when loaded with a volume of 21.4 cubic inches.

Based on the value of 1.8 seconds for the nozzle-flapper and 0.03 second for the relay (reduced from 0.4 to account for the smaller capacity present when the test was made on the controller) and on the values of gain mentioned previously, ($K_{fb} = 6 \times 10^{-3}$ and $k_{nr} = 1.25 \times 10^{4}$) the values for $\mathcal{J}$ and ω_n were calculated.

The results of the observed $\mathcal{J}$ and ω_n from the sinusoidal test of the controller and the calculated values, computed as mentioned above (see Equation 52) are presented in graphical form in Fig. 28.

The correlation between calculated and observed results is not especially good, the average error being about 30 to 40 per cent. The error in any particular set of results may well be much higher than this. On the other hand, the results are reasonable enough to substantiate the trend expected and serve to indicate that further investigation along the lines indicated should prove fruitful.

Appendix I

Terminology

The term static sensitivity is defined by Fig. A-1.

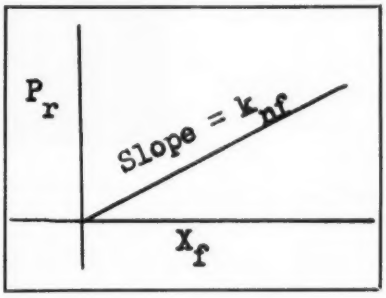

Fig. A-1

X_f is the steady value of displacement and P_r is the resultant steady pressure. k_{nf} has been termed the proportional response. Another, and preferable, term is "frequency-invarient" gain. In the servomechanisms field the word "gain" is employed for k_{nf}.

Appendix II

The quantities introduced with reference to Equation 17 are defined as follows:

$$\frac{T_x}{T_R} = \frac{1}{2}\left[1 + 3y + \sqrt{1 + 2y + 9y^2}\right]$$

$$\frac{T_z}{T_R} = \frac{y}{T_x/T_R}$$

$$\alpha_x = \frac{A}{T_x/T_R}$$

$$\alpha_z = \frac{\alpha_x}{1 + \frac{K_L}{5}}$$

$$2A = 1 + K_L + 3\left(1 + \frac{K_L}{5}\right)y + \sqrt{\left(1 + K_L\right)^2 + 2\left(1 + \frac{K_L}{5}\right)\left(1 + 3K_L\right)y + 9\left(1 + \frac{K_L}{5}\right)^2 y^2}$$

$$y = T_d/T_R$$

$$0 < y < 1/3$$

Acknowledgment

We gratefully acknowledge the help of the Foxboro Company in supplying the controller, components and some of the data used.

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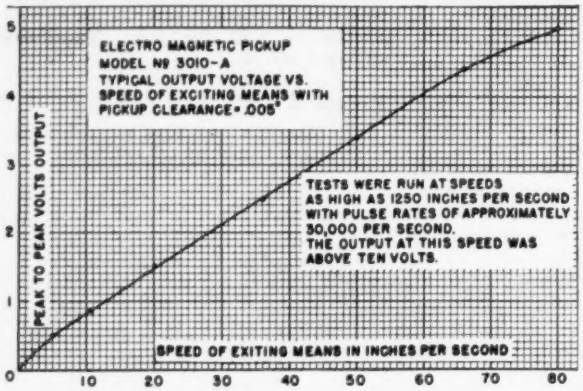
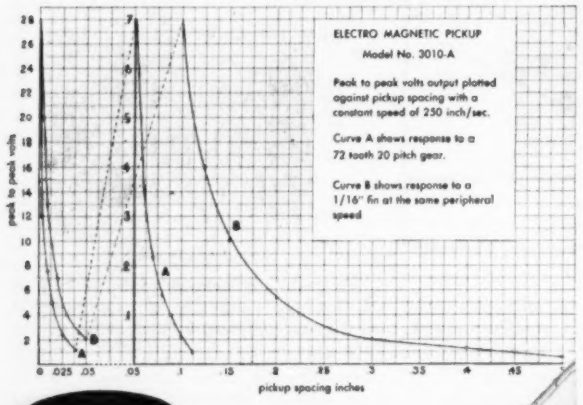


Performance at Constant Speed with Variable Spacing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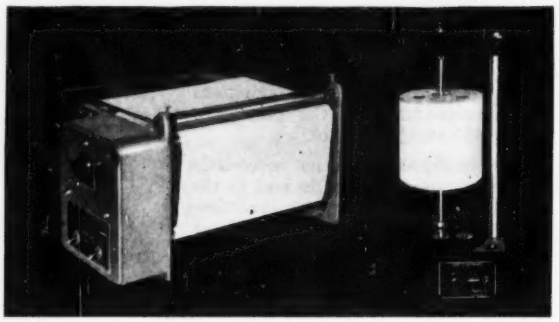

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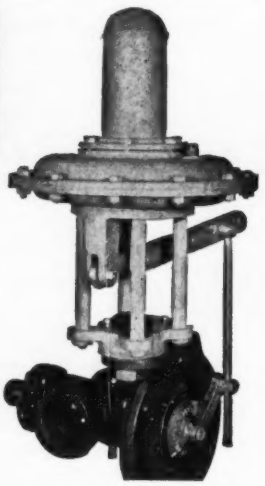

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Positive-displacement Metering of Liquids

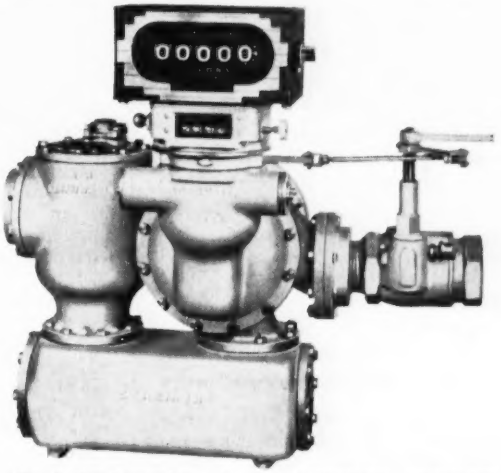

Fig. 1. Truck-metering unit with air eliminator, "Rotocycle" meter (under register), predetermining valve, and strainer.

Basic types of positive-displacement meters are the reciprocating-piston, rotary, oscillating-piston, and nutating-disk types. Operational factors include micro adjustment, temperature correction, samplers, remote registration, predetermining register, rate-control valves, air eliminators, and strainers.

By RICHARD F. McCORMICK
Rockwell Mfg. Co.

DEVICES for measuring flowing fluids may be divided into two classes—(1) inferential meters (orifice meters, dilution meters, thermal meters, area meters, venturi meters, etc.), which measure some property of the flowing stream which varies with flow rate and infer rate of flow from the measured property, and (2) positive-displacement meters, which continuously separate the flowing stream into parts of equal volume and count the parts.

Inferential meters are easily installed, are used where an accuracy within 1 to 5 percent is satisfactory (higher accuracies are obtained only between 100 and 40 percent of rated flow), and where measurement of *rate* of flow is of primary interest. Positive-displacement meters are used where a high degree of accuracy (0.1 to 1 percent) over a wide range of flow is desired, and where a measurement of total quantity passing the meter is of primary interest. This article discusses some of the common types of positive-displacement meters and accessories.

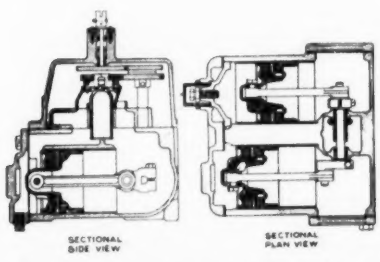

Fig 2. "Pittsburgh" 1-inch reciprocating-piston meter.

Reciprocating-piston Meters

The reciprocating-piston meter is one of the oldest of the positive-displacement liquid meters. The meter was used extensively in petroleum metering about twenty years ago, but has now been replaced by rotating-type meters for large-capacity service. It remains, however, without peer in its special field—where extreme accuracy at low flows is a basic requirement. This requirement generally arises where the liquid being handled is relatively expensive or heavily taxed.

The reciprocating-piston meter is similar in principle to the steam engine, from which it probably evolved. Measurement is accomplished by one or more pistons moving back and forth in cylinders, this movement being appropriately transferred to an indicating device. The liquid is directed by a valve so timed that the flow is kept constant, with a minimum of pulsation. Many variations have been built around this principle. The number of pistons varies from one to five, the valves rotate or slide, the stroke is governed by various means, and the pistons are sealed with cups, with rings, or with a capillary seal effected by close clearances between piston and cylinder. A number of adjusting devices are used on piston meters, the most common being the changing of the stroke of one or more of the pistons.

The largest single use for reciprocating-piston meters today is in gasoline service-station pumps. Since World War II about 100,000 of these pumps have been built each year; piston meters have been used almost exclusively. A typical meter of this type is shown in Fig. 2.

Prior to March 1, 1935, beer was measured for tax purposes by gaging in locked government tanks before bottling or racking. This function was performed by a federally employed gager who unlocked the tanks after gaging so that the beer might be packaged. As this inflexible arrangement was unsatisfactory to both brewer and government, most breweries were

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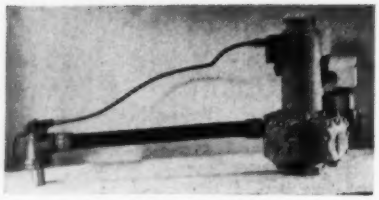

Fig. 3. Drum and can filler.

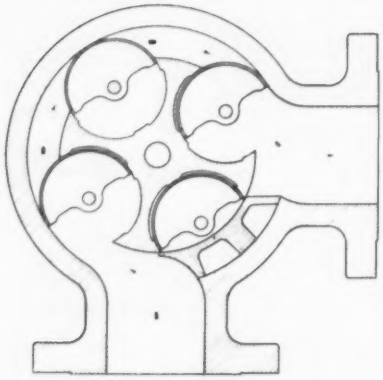

Fig. 4. "Type BLX Rotocycle" meter.

equipped with government-approved beer meters after March, 1935. All meters approved by the government for this service are reciprocating-piston meters.

The reciprocating-piston meter is used also in drum and can fillers, where high accuracy is important. Fig. 3 shows one such unit complete with temperature compensator, predetermining mechanism, and non-drip delivery valve. In service this unit has consistently repeated five-gallon deliveries within one cubic inch. Increasing in importance is the metering of liquefied petroleum gas, and piston meters designed for high pressures and constructed of suitable materials have proven suitable.

Rotary-type Meters

Fig. 1 shows a Rockwell "Rotocycle" meter, which is typical of the rotary type of meter. Fig. 4 illustrates its principle. Four semi-cylindrical vanes are mounted on a rotor which is free to rotate about its own center. These vanes turn about their axes and are mechanically maintained in the same positions relative to each other and the stationary parts of the meter. During any part of a revolution of the rotor, at least two vanes are so close to the housing that surface tension creates an effective seal. The flowing stream is thus separated into parts of equal volume, as contained between the vanes. The count of the revolutions of the rotor, accomplished by suitable gearing between it and the counter or register, indicates the volume of liquid passing through the meter. All rotating parts are carried on low-friction bearings and, as there is no other mechanical contact between moving and fixed parts, the power absorption of the meter is low. The meters are accurate throughout their operating range, which is generally from maximum capacity to 20 percent of maximum capacity. The "Rotocycle" meter is constructed in various sizes from 20 to 800 gallons per min. maximum capacity, and working pressures from 125 to 1500 psi.

Oscillating-piston Meters

Another type of positive-displacement meter is the oscillating-piston meter (Fig. 5). A cylindrical piston operates in an annular chamber which is ported to introduce liquid on one side of a division plate. The path of the piston is controlled by the annulus walls and the division plate, which form pressure seals so that the pressure differential forces the piston to move in an oscillating path around the annulus. The meter is used widely for metering water; it is used also for metering industrial liquids and petroleum products.

Nutating-disk Meters

When accuracy requirements are not too stringent, a meter of the nutating-disk type is satisfactory. Although this type of meter is used most generally for the metering of water, it is used also in considerable quantities for the metering of petroleum fuels.

The counter, or register, is actuated by the displacement of a disk mounted in a measuring chamber having a conical top and bottom. The disk is mounted so that it is always tangent to the top cone at one point, and to the bottom cone at a diametrically opposite point. In the measuring chamber, a partition extends half way across, with a slot in the disk to take this partition. Liquid enters the measuring chamber at one side of the partition; passes around and through the measuring chamber, and out on the other side of the partition. Liquid entering either above or below the disk must move the disk in order to pass. The resulting wobble, or nutating motion, of the disk causes its axis to describe the surface of a cone having a vertical axis and an apex in the center of the disk. The disk does not rotate, but the rotary motion of its axis is transmitted to the counter through suitable gearing.

Tank-truck Metering

Tank-truck metering is a rapidly growing practice that requires the utmost in accuracy and dependability while imposing strict limitations on size, weight, and arrangement. It is also an application of metering that is subject to much abuse. The tank-truck meter unit usually consists of an air eliminator, strainer, meter, and predetermining valve assembled in as compact a unit as possible to conserve space and weight. All component parts are accessible. Flow lines should be as direct as possible to eliminate unnecessary pressure loss.

Fig. 1 shows a truck metering unit composed of an air eliminator, strainer, "Rotocycle" meter and predetermining valve. In operation, the fluid from the tank truck compartment is drained or pumped into the air eliminator on the left side of the unit, down through the strainer (the housing of which forms the base of the unit), through the meter and predetermining valve on the right-hand side, and into the dispensing hose. Tank-truck units are rated for operating pressures up to 125 psi. and flow rates up to 200 gpm. There is an increasing demand for higher capacity units.

Micro Adjustment

Different positive-displacement meters of the same design have slightly different displacements per revolution because of manufacturing tolerances, and normal wear during the life of a meter may change the displacement slightly. As a meter may be required to register correct volumes with extreme accuracy, means must be supplied to vary the volume indicated per revolution of the meter. One means for doing this is by use of an adjustable drive, or micro adjustment. The micro adjustment consists essentially of two over-riding clutches, with the main drive from the meter transmitted through one over-riding clutch to the register. Means are provided for a third member to drive the register faster than the meter drive for a portion of each revolution, through the second over-riding clutch. Thus, for each revolution of the meter the register turns one revolution plus the portion of a revolution which is added by the adjustment. The magnitude of the added motion can be varied. Within its range, the number of different ratios possible is infinite.

Temperature Correction

The value of most petroleum products is determined by their energy content, which is a function of the mass of the liquid rather than its volume. The specific volume and density of all

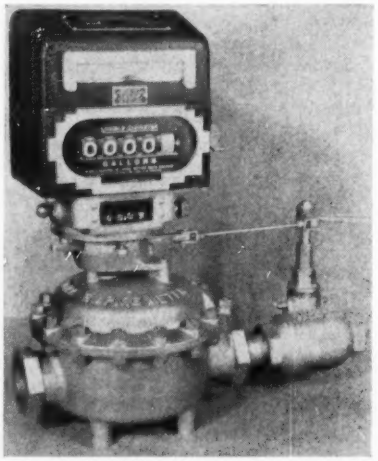

Fig. 5. Oscillating-piston meter with predetermining mechanism.

liquids vary according to the temperature of the liquid. To establish the value of a given volume of a liquid without converting it to weight, the volume must be corrected to a standard base temperature. To make this correction automatically, a pressure thermometer is inserted in the liquid line to vary the setting of a micro adjustment. The meter can then handle liquid at any temperature within the range of the temperature compensator, and the volume corrected to a standard base temperature is recorded on the register.

Where petroleum products are metered, it often is desirable to have a record of the actual volume as well as the volume corrected to a given temperature. This can be done by providing means whereby the meter drives two micro adjustments and two indicating registers. A temperature bulb is installed in the liquid stream and the movement of this bulb is used to bias one of the micro adjustments. This results in one of the registers indicating actual volume and one indicating volume corrected to a given temperature.

Samplers

As an adjunct to metering, it often is desirable to determine the physical characteristics of the liquid being metered. For example, crude oil often contains water. To permit determination of the proportions of water and oil in the crude being metered, samplers have been devised. These are controlled by action of the meter and extract small quantities from the flowing stream at predetermined and regular volumetric intervals. These small quantities are collected in a container and then analyzed, either visually or in the field or in the laboratory to determine the water and oil content. Fig. 6 illustrates a combination piston meter and sampler used for metering crude oil.

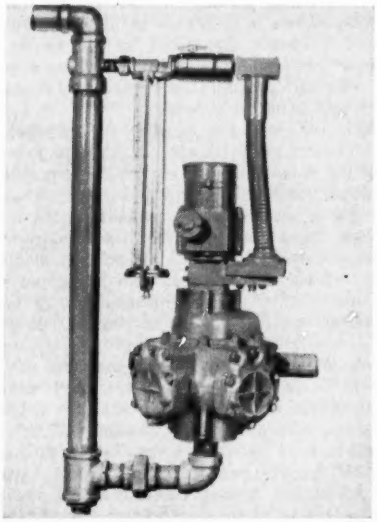

Fig. 6. Crude-oil piston meter and sampler.

Remote Registration

It is often desirable to transmit the register reading to a distant point. This is particularly true at loading racks where tank trucks are filled at the rack and recording and accounting is done in an office or control station some distance away.

Fig. 7 shows a battery of receiving elements of a remote registration unit. This unit consists of a transmitter and receiver, identical in construction and acting in exact synchronism through the use of synchro motors. The transmitter is mounted between the meter and the register, and is electrically connected to the receiver in the control room. This arrangement permits the truck operator to see and control the delivery to his truck and, at the same time, permits the man in the office to note and record the amount delivered. Ticket-printing registers are used on the receivers to facilitate recording.

Predetermining Register

Positive-displacement meters often are equipped to deliver automatically a definite quantity of a liquid. The equipment consists of a predetermining register (on which the desired quantity is set) and linkage from the predetermining register to a predetermining valve. When the meter has delivered the preselected volume, the predetermining register trips the valve control mechanism and the valve closes. This mechanism is used to load and unload tank trucks and for various industrial batching operations. Fig. 1 shows a "Rotocycle" meter with predetermining register, linkage, and valve.

Rate-control Valves

When two or more meters are operating in parallel from the same supply and some of the meters in the parallel system are shut down, there is some danger that the meters remaining in operation may be damaged by over-speeding. This hazard is present at loading racks where several meters are supplied by one pump. Also, to obtain greater accuracy range than a single large meter permits, some pipeline flows are measured through a parallel battery of meters with no single meter in the battery large enough to take the entire full flow of the pipeline. To protect such meters, many installations include rate-control valves. These vary in principle, but generally operate to maintain some constant value for static or velocity head somewhere in the flow stream, near or at the meter.

Air Eliminators

An air eliminator (Fig. 8) is a device for separating and releasing air from the flowing liquid, and for absorbing shocks and impact pressures in the line. In any liquid metering system where air can enter and mix with the liquid, or where temperature changes cause vaporization of the liquid, an air eliminator is necessary to prevent entrained air and vapor from being metered and registered as liquid. As liquid enters the eliminator the velocity of the flow decreases because of the large capacity of the tank, allowing time for the air to rise to the top of the eliminator, where a quantity of air is constantly maintained to absorb shocks. As the air continues to accumulate, the level of the liquid is forced downward, allowing the float to drop, which in turn opens the air-release valve. The excess air escapes and the fluid level rises again, lifting the float and closing the air-release valve.

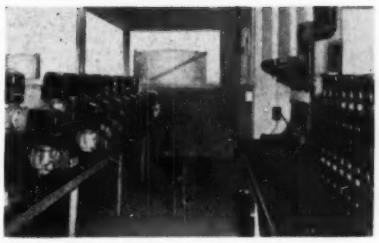

Fig. 7. Remote registration units.

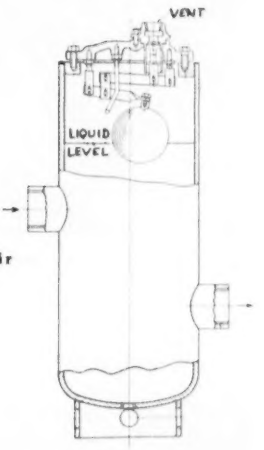

Fig. 8 Air eliminator.

Strainers

A strainer is a simple device, but an important and necessary one in a metering system. It prevents dirt and foreign particles from entering the meter, where they might cause considerable damage. Dirt and foreign particles are trapped and accumulated in a basket. At regular intervals the strainer basket must be emptied.

Although meters are constructed to withstand normal loading and wear conditions, they are precision instruments and should be treated as such. Manufacturer's recommendations as to installing, adjusting, and servicing should be observed carefully. Care should be taken in the mounting of meters to see that they cannot be unduly stressed by the weight of external piping and equipment. Whenever possible it is recommended that after the installation is completed the working parts of the meter be removed and the whole system flushed until it is clean.

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PROCESS MONITORING

Continued from page 1016

may correspond to five or ten degrees of temperature, unless the circuit is carefully balanced. By carefully balancing the circuits, high-speed scanners can be designed to operate at 20 points per second with an accuracy of about plus or minus 2 degrees C.

Fig. 7 shows a mercury jet switch developed at General Electric Company, Richland, Washington (described by Rodney Huff in a paper, 52-1-3, ISA Conference, September, 1952). This switch is operated by a jet of mercury driven by the rotating cone so as to impinge on platinum pins located around the periphery of the unit. The author states that it has been operated at rates up to 1800 points per second with a noise level of only 20 microvolts across 20 ohms. Although this switch is not available commercially, its development should open up possibilities for much higher scanning rates than have been possible with ordinary stepping switches.

Indicating Systems

Indicating the temperature is of little significance in a scanning system because of the high speed at which the points are monitored. For this reason, indicators or recorders usually are operated only during abnormal conditions, when the scanner is stopped or slowed down to make the indication readable. In a high-speed scanner the detector is usually an electronic amplifier, entirely independent of the registering instruments.

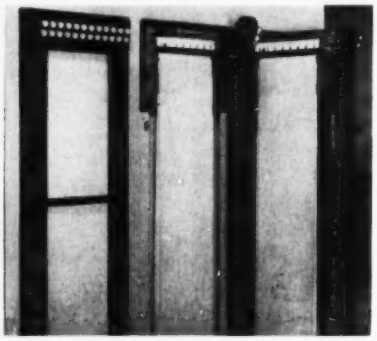

Fig. 9. Multiple-band strip-chart recorder.

Several ingenious methods have been devised for indicating abnormal conditions. Fig. 8 is a scanner equipped with a coordinate lighting system to show the location of the point being scanned. When any point exceeds a high or low limit the lights, together with the annunciator system at the top of the panel, show which point is causing the alarm; the annunciator system shows whether it is high or low. The recorders are not normally connected to the system when it is operating at high speed, but the speed can be slowed down by the operator so that the recorders can be connected and a chart made of all points.

The plug and jack board serves a number of purposes. The recorders can be continuously plugged in to any point or groups of points which it is desired to study; these points are then recorded independently of the main scanner. They can also be plugged into a second set of jacks (located on the sloping shelf below) which are connected to a high-speed scanner with only two hundred points. This auxiliary scanner monitors the unit at very high speed and makes sure that selected points are within their desired limits, even while the master scanner is slowed down during a recording cycle.

An alternate method of mapping high-speed scanners (described in the paper by Huff, referred to previously) uses a large oscilloscope energized in synchronism with the main scanner. Any deviation is recorded by the intensity of light spots on the tube. This type of unit is probably limited to between 50 and 100 points per tube and might thus be fairly costly. Furthermore, visual recognition of variable light intensities might offer problems from the standpoint of eye fatigue.

Another method that has been used successfully is the substitution of neon lamps in a coordinate system, and triggering these lamps by the amplifier detector whenever any point deviates beyond its predetermined limits. This is accomplished by adding another row of switch contacts to the stepping switch, thus selecting the corresponding lamp for each thermocouple. Once the lamp is triggered by a voltage above the ignition voltage, it will stay until it is manually reset by removing the biasing voltage. This system has been operated successfully at a speed of over 20 points per second.

Automatic Scanning Recorders

Early scanners were equipped with standard strip-chart or round-chart recorders, which are still satisfactory for many purposes. However, it has been necessary to go to other types when monitoring large quantities of information at high speeds in a relatively small space.

Fig. 9 is a 576-point segmental recorder, developed by du Pont and constructed by Panellit, using the basic mechanism of a Minneapolis-Honeywell strip-chart single-point recorder. This recorder operates at 2 points per second, using a ballistic printing mechanism. Each daily chart consists of a 12-foot continuous roll of standard strip chart, 12 inches in width. At the end of each day it draws 144 curves, each 6 inches long and each using 1/6th of the width of the chart. Each point on the curve is actually four consecutive readings from four thermocouples; thus each six inches of chart travel superimposes the readings of four group thermocouples. The mechanism will be described in a paper by L. P. Haner of du Pont, at the ISA Conference at Chicago, in September, 1953.

Digital-Type Recorders

Recently a number of large scanners have been equipped with digital converting mechanisms so that the recording can be performed by a standard "Teletype" automatic typewriter, or tape recorder. A number of these recorders are available on the market and can be readily coupled to scanners, but before this can be done the readings must be transformed from voltages into digital units, either in the form of on-or-off impulses or selective switching positions.

Digital converters are generally of two types—electromechanical or electronic. Electromechanical converters are merely switches which are positioned by the potentiometer mechanism (or its equivalent). In the electronic converter the voltage is fed directly into an amplifier which triggers a number of individual vacuum-tube circuits, each of which controls a relay. For each decade, four such triggering circuits are necessary—for 100 numbers, 8 circuits or channels are necessary; for 1000 numbers, 12 circuits are needed.

One multiplex coding system which is usually adapted for wire transmission consists of five channels, each requiring six wires, and gives a coding of one decade from 1 to 10 and a complete alphabet (with the punctuation marks usually included) on a standard typewriter. The coding systems usually used in "Teletype" work consist basically of pulse trains of both positive and negative polarity; transmission may thus be accomplished with a single circuit.

"Teletype" System

Any standard "Teletype" unit or automatic typewriter can be operated from a scanner having the proper digital converter. Fig. 10 is a standard, electrically driven, automatic typewriter, which can be completely operated by a five-channel digital converter. Although this typewriter is equipped with keys, these have nothing to do with the automatic recording. The keys merely permit an operator to add notations or headings to the chart. The automatic tape-punching and tape-reading device is at the side of the typewriter. The rear section of this device punches holes in a roll of tape. This tape then can be fed into any IBM or similar machine for recording on a master punch-card system if desired. This tape can also be re-run through the tape reader shown at the front left and the entire message thus re-typed. Fig. 11 is a typical chart made from this typewriter.

These machines, which are available on the market, can

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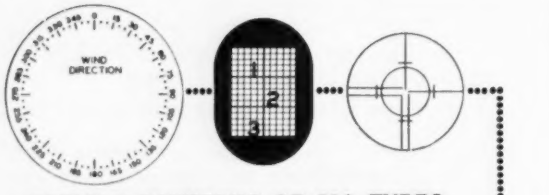

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integrate the recorder readings into any statistical-analysis system of the plant accounting system. In one large installation where analysis on a statistical basis forms an important part of the research work in improving the process, every reading on the tape is transferred to a separate IBM card. At a moment's notice, therefore, a study can be made of the characteristics of any single point, or any group of points, or any point that deviates beyond any predetermined temperature limit—merely by using the standard techniques of the punch-card system.

Memory Circuits

When recorders are used in connection with scanners, it is usually necessary to slow down the scanner while the record is being made because of the slower operating speed of recording systems. An alternate method, where slowing down is undesirable, is the use of memory circuits. These consist of capacitors or magnetic circuits and a switching circuit, which is so arranged that when several alarms occur in rapid succession, the memory devices are immediately charged to different values of voltage by the scanning detector. It is only necessary for the scanner to be connected to these memory devices for a short time and then move on to a next point, but the charge can be retained for ten minutes or more.

Fig. 10. Automatic typewriter.

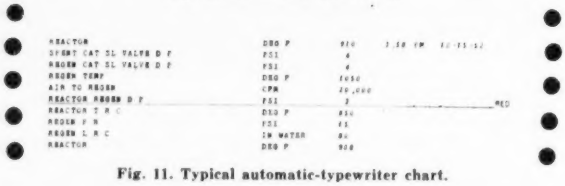


Fig. 11. Typical automatic-typewriter chart.

When a capacitor memory device is charged and the scanner moves to the next point, this capacitor is connected by a switch to the digital converter, which sets up the reading for the "Teletype" or typewriter. It may take 5 to 10 seconds for the recorder to finish typing the entire message, which may extend across an entire line. When the message is finished it actuates a switch, which snaps the typewriter back, makes it ready for the next position, and connects the digital converter to the next memory circuit which was charged by the scanner. The typewriter then proceeds to type the second message and so on, until all of the alarm points are accounted for.

As each memory circuit and switching circuit adds to the expense, it is not normally the practice to utilize more than ten, twenty, or thirty memory circuits even in a scanner having several thousand points. In addition, it seldom happens that more than twenty or thirty alarms go off at one time; if they do, it usually means a breakdown that involves a complete shutdown of the system. Even during a complete shutdown, however, it is desirable to know which of the alarms were the first ones to go off, thus making it possible to make a study of the events that lead to the shutdown. Therefore, the number of memory circuits can be limited to the number of initial points that might have to be studied. It must be kept in mind that twenty memory

circuits will clear out in slightly over a minute; therefore, if more alarms come on after the typewriter has finished work, they will be registered properly.

Ferromagnetic devices and magnetic-tape recorders also have been used for memory circuits. To date, however, most scanners have used the capacitor type of memory circuit.

Conclusion

A number of factors are making the automatic scanner fill an ever-increasing role in modern process control. The increased number of repetitive readings and the ever-increasing demands on the operator's judgment and speed of reaction will make it more and more difficult for him to rely on individual instruments. The rapid development of new chemical processes will increase the requirements for large masses of information for purely research and statistical analysis. Finally, the development of standard components such as decade switches and master units, automatic "Teletype" recorders, and digital converters will increase flexibility to such an extent that large systems can be built up entirely around standard units. This will eventually bring the cost per point monitored down so that the scanner can compete with the ordinary indicating system even in systems below 100 points, and thus a new tool will be placed in the hands of the designer of the modern process control system.

SIZING VALVES

Continued from page 1019

Water and Steam Mixture

We have considered only flowing conditions where water was in the liquid state at the valve inlet. The two curves marked 340 and 350 deg. in Fig. 3, and those marked 308, 328, and 344 deg. in Fig. 8, represent flow with a mixture of water and steam at the body inlet. The values marked on the curves are temperatures at the storage tank. The temperatures at the valve inlet, where there is a mixture of steam and liquid, must necessarily be the saturation temperature for the inlet pressure. In Fig. 8, where the inlet pressure is 50 psia., the inlet temperature would be 281 F.

Note that as soon as the water absorbs enough heat to reach the saturated liquid state, its pressure-drop vs. flow-rate relationship approximately parallels that of steam, and that its critical pressure ratio also becomes approximately the same as for steam. Because of the similarity between the steam flow and the vapor-liquid mixture flow, it would seem logical to base the sizing of the vapor-liquid mixture on the steam flow multiplied by a factor.

As valve inlet temperature is no indication of the heat content of a mixture of liquid and vapor, "percent of flash at valve inlet" has been used as the ordinate in Fig. 9; this means the percent by weight of the water that is in the vapor state, and was determined from thermodynamic considerations.

The value of K_g on the abscissa are the factors by which

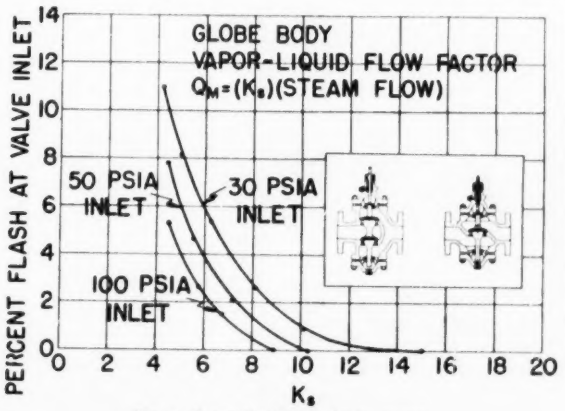
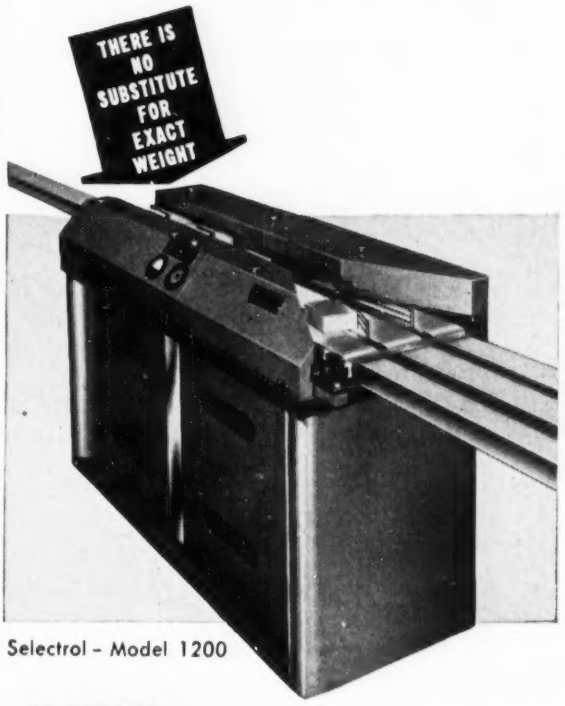


Fig. 9. Vapor-liquid flow factor curves.



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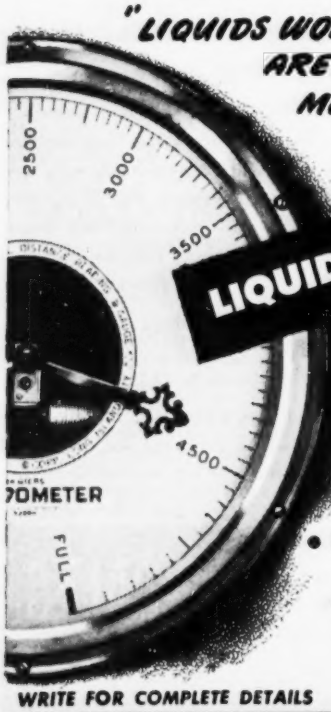

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the theoretical steam flows must be multiplied to equal the flow of vapor-liquid mixture.

Thus the procedure for sizing a control valve when the water is in a vapor-liquid state at the valve inlet would be as follows:

1. Determine the percent, by weight, of flash or vapor at the valve inlet by thermodynamic methods.
2. From the curves, Fig. 9, determine the factor K_s for the given inlet pressure.
3. Determine the amount of saturated steam the valve would pass at the given pressure condition.
4. Multiply the steam flow by the factor K_s. This could be expressed by the formula

$$Q_m = (K_s)\ (Q_s)$$

where Q_m is quantity of vapor-liquid mixture in lbs./hr., K_s is factor from curve Fig. 8, and Q_s is theoretical steam capacity in lbs./hr.

Angle Bodies

Preliminary tests showed that flow through single-seated angle-style bodies in the direction of closing the inner valve did not follow the same laws as globe bodies. Fig. 10 illustrates results of a series of tests on a 2-inch x 3-inch Sweep-Flo-Type angle body with a 1½-inch diameter throttle-plug inner valve. These tests were run with 100-psia. constant inlet pressure and with other conditions similar to those used in the 2-inch double-ported globe-body tests illustrated in Fig. 3. Note that with a 200 F. inlet temperature, the apparent critical pressure drop for this angle body is 19 psi., as compared to a critical drop of 70 psi. for the same inlet temperature and pressure with a globe body (Fig. 3).

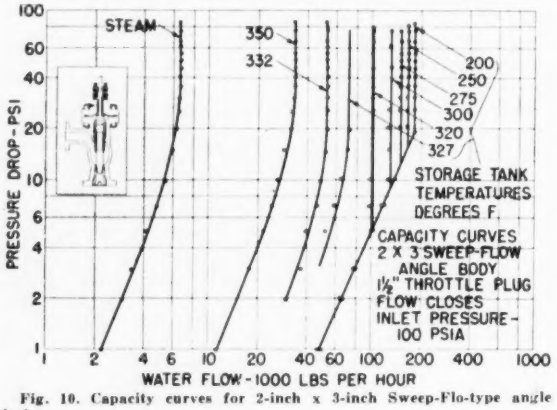

Fig. 10. Capacity curves for 2-inch x 3-inch Sweep-Flo-type angle body.

In addition to the streamlined Sweep-Flo-type of bodies, the more or less standard type of single-seated angle valves with various body and orifice sizes also were tested. The comparative results of some of these tests are shown in Fig. 11.

The "inlet saturation temperature minus actual inlet temperature" has been plotted against "allowable pressure drop factor." The body type and orifice diameter are marked on the curves. The dashed-line curve labeled "globe body" has been copied from Fig. 6 for comparative purposes. Note that the 2-inch x 3-inch Sweep-Flo curve is asymptotically approaching an allowable pressure drop factor of 0.20. This means that it should not be sized for pressure drops greater than 20 percent of the inlet pressure. Data from different orifice sizes in 2-inch standard angle bodies follow widely separated curves.

From these curves it is evident that it is not possible to consolidate the angle-body test results into any general sizing rule.

Whereas the angle-style bodies have high C_V's, or flow coefficients, due to the fact that their allowable pressure drop factor or point of critical pressure drop is so low, their capacity is considerably less than that for globe bodies at high pressure drops and temperatures near saturation.

Tests were run also with angle bodies installed so that the direction of fluid flow tended to open the inner valve. Re-

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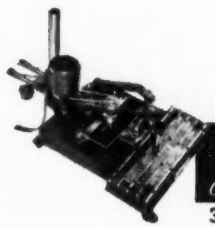

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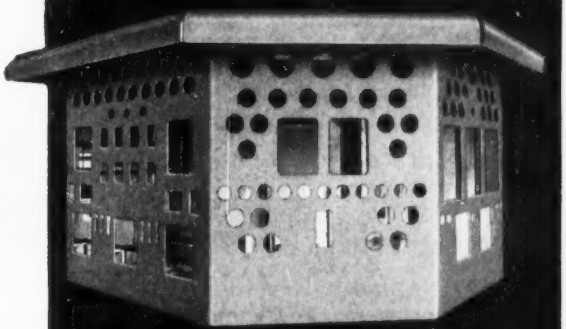

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sults indicated that critical pressure ratios with this method of installation were almost identical to those for globe bodies. Capacities were also equal to those of globe bodies. Double-ported angle bodies were not tested, inasmuch as they are not widely used.

Conclusions

The quantity of liquid flow through an orifice of a control valve is a function of the pressure drop, or the difference between entrance and exit static pressures.

The maximum attainable inlet pressure is determined by elevation, pumping equipment, etc. The minimum attainable orifice outlet pressure is the vapor pressure of the liquid at the flowing temperature. Since the static pressure decreases with increasing velocity, it is logical to assume that at some pressure drop the increased velocity at the valve orifice exit will result in a static pressure equal to the vapor pressure in the liquid. When this condition of vapor pressure in the region of the valve orifice has been reached, the valve orifice is passing its maximum capacity for the given inlet pressure and flowing temperature, and further reduction in static pressure in the downstream piping will not result in increased flow. The pressure drop at which this phenomenon takes place has been referred to as *apparent critical pressure drop.*

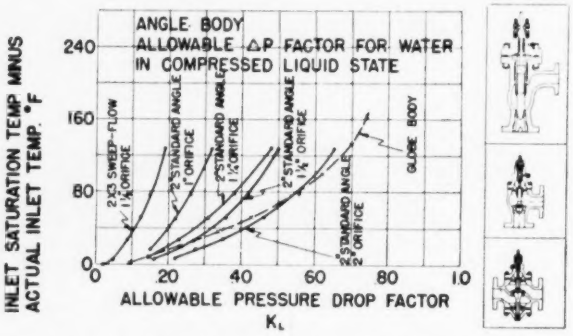

Fig. 11. Allowable-pressure-drop-factor curves for angle bodies.

As the vapor pressure of a liquid is a function of its temperature, or enthalpy, it seems logical that enthalpy might be considered as a factor in determining capacities of control valves handling liquids.

Exhaustive tests have shown that for all practical purposes, apparent critical pressure ratios for single- or double-ported globe bodies with plug-type or V-port inner valves handling water are dependent on heat content of the water only, and can be predicted with reasonable accuracy. A method based on this fact for accurately sizing control valves handling water has been presented.

Angle-style bodies installed in the conventional manner with flow tending to close the inner valves have been found to have considerably lower apparent critical pressure ratios than globe bodies and, consequently, less capacity at higher pressure drops and temperatures. This is probably due to less turbulence and increased orifice exit velocity. Actual apparent critical pressure ratios were dependent on body size, details of body and orifice design, and ratio of body to orifice size. No comprehensive method of sizing angle bodies was discovered.

It is the recommendation of the authors that angle bodies should be used with caution unless they are installed in reverse of the conventional manner so that flow tends to open the inner valves. If installed in this manner they can be sized by the same methods used on globe valves and will have essentially the same capacities.

The data and conclusions presented apply only to water, but it is reasonable to assume that similar data on other liquids would lead to similar conclusions. From this it appears that in order to intelligently size a control valve handling liquid, the vapor pressure of the liquid should be considered, as well as the inlet and outlet pressures, temperature, viscosity, specific gravity, and required rate of flow.

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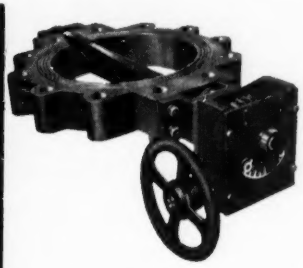

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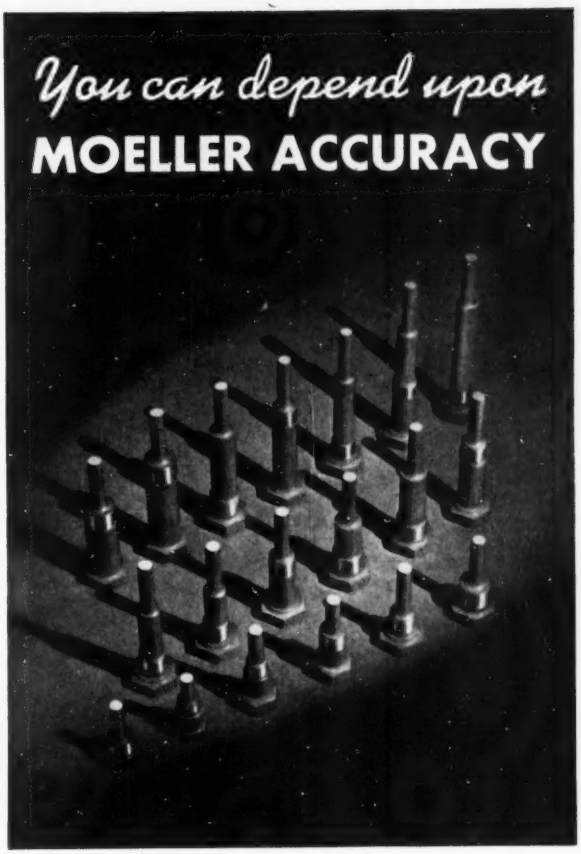

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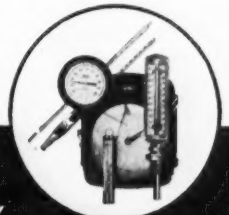

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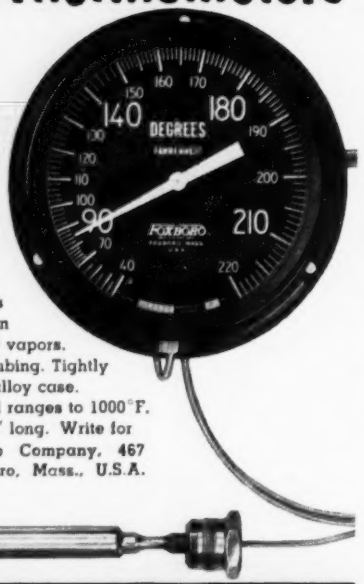

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PROCESS CONTROL

Continued from page 1021

7-5. This limits the amount of derivative action which can be used, as shown by the following example:

By adding derivative action, which produces a phase advance (Fig. 7-4) to a proportional controller, the phase lag of the controller can be reduced to less than 180 deg. For example, for a value of $T/R = 8$, the phase advance is 40 deg.

The controller phase lag is therefore $180 - 40 = 140$ deg.; the period (T) of the plant with characteristics plotted in Figs. 6-3 and 6-4, which gives a phase lag of 220 deg., is 10 minutes. The attenuation for $T = 10$ minutes is 20 and, therefore, to obtain sustained oscillation $\mu = A = 20$.

Note that with proportional control alone on this plant, sustained oscillation was given by $\mu = 10$; that is, by a proportional band twice as wide.

Once T is known, the required value of the derivative action time (R) is found from $T/R = 8$. In this instance $T = 10$, and hence $R = 1.25$ minutes.

Fig. 7-5 shows that the gain factor in this example, for which $T/R = 8$, is negligible.

If T/R is now taken as 4, the phase advance = 57 deg. (Fig. 7-4) and the gain factor = 1.9 (Fig. 7-5).

Using Figs. 6-3 and 6-4, the period which gives plant phase lag of 237 deg. is 7.5 minutes; the attenuation at this period is 27. The total controller gain must therefore be 27 (to give continuous oscillation), and as we have a gain factor of 1.9 due to the derivative action, $\mu = 27/1.9 = 13.5$. At period 7.5 minutes, $T/R = 4$ gives $R = 1.9$ minutes.

In this example we have increased the over-all gain of the controller to 27, but we have reduced μ to 13.5; however, the period has been reduced to 7.5 minutes. It is clear that the derivative action time must be chosen to give the best control according to the conditions and requirements.

To find μ for e/1 damping with proportional plus derivative action, the same procedure is applicable as for undamped oscillation, but the 10-percent addition to the phase lag must be made in the frequency-response diagram. The dotted curve in Fig. 7-5 must therefore be used.

The important points regarding use of derivative action are: (i) It permits the use of a higher μ and narrower proportional band than would be possible with proportional control alone; (ii) it will, by permitting a higher μ, assist in reducing offset; (iii) it will, from its primary function, reduce peaks due to rapid changes in conditions; and (iv) as the derivative-action time R is increased, a limit is reached at which any further increase in R leads to worse control. Instability becomes evident and increases rapidly with any increase in R. The reason for this is apparent because the over-all gain is now too high and the oscillations are being amplified instead of being reduced. When used correctly, derivative action is a stabilizing factor in control.

Equation for Proportional plus Derivative Control

The output of the controller is the sum of the proportional and derivative outputs, and the total potential correction (Θ) is the sum of the two potential corrections:

$$\Theta = -\mu\ (\theta + R\ d\theta/dt) \qquad (5)$$

Proportional plus Integral plus Derivative Control

The equation for a controller with the three basic control actions is:

$$\Theta = -\mu\ (\theta + 1/S \int \theta dt + R\ d\theta/dt) \qquad (6)$$

The factors μ, S, and R are not independent in many pneumatic controllers. Hence, if the settings are made on the controller (and the dials are correctly calibrated in R and S for independent action) the *effective* values of derivative and integral action times will not be as set. The practical significance of this fact will be considered in the next installment, which will deal with the principles of operation of typical pneumatic controllers with proportional, integral, and derivative action. Some practical suggestions will also be made for setting up such controllers on the plant.

To be continued.

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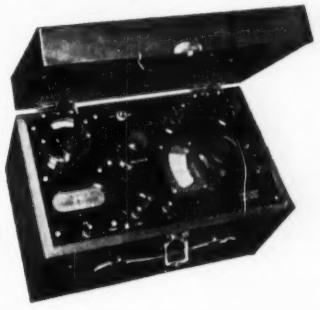

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INSTRUMENTS ON THE MARCH

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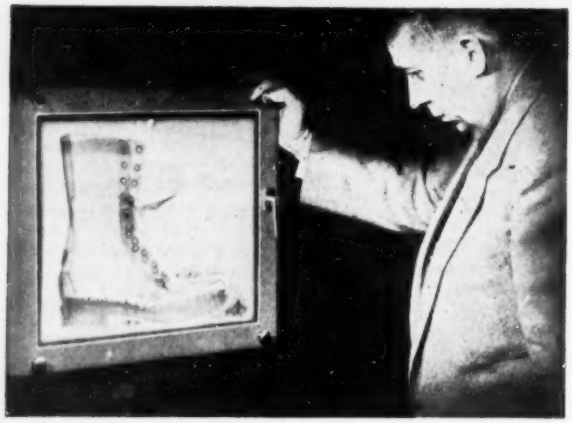
Fluoroscopic X-ray Inspection

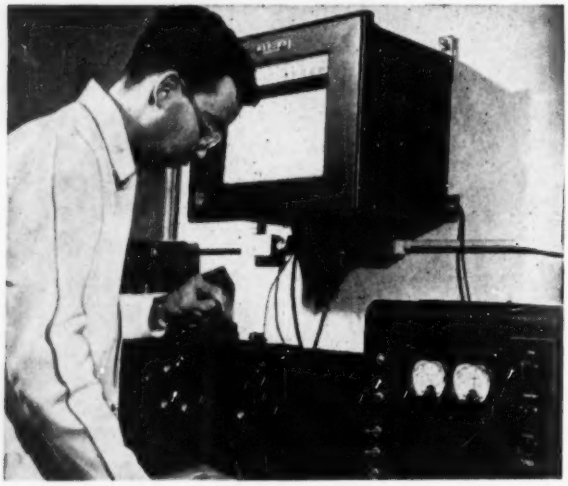
NEW YORK, N. Y.—Fluoroscopic X-rays dramatically reveal flaws in military footwear, as shown in this view of a new GE X-ray unit being inspected before delivery by



Mr. Albert Wiebe, Chief, Instrument Engineering Office, Quartermaster Inspection Service, New York City. Note the misplaced nail in the heel. The boot may be rotated while in the X-ray beam by means of a dial located beneath the fluoroscopic screen.

Flavor Measurement

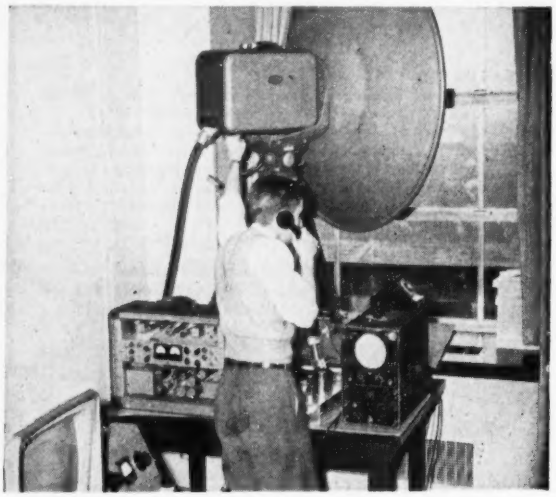
MAYWOOD, ILL.—This scientist is "taking a picture of a flavor." The unusual test, one of the hundreds of research experiments conducted at American Can Company's Maywood, Ill. laboratories, analyzes an orange-juice sample. The



results from the spectrophotometer test are charted on the Honeywell-developed electronic recording instrument (center) which serves as a control for subsequent testing operations. Exacting tests such as this help develop new containers and techniques for the canning and can-making industries.

Portable TV Relay

BOSTON, MASS.—Operator of the new, portable "Microlink" TV relay "zeroes in" his parabola from an upper story of the John Hancock building in Boston, on the opposite unit



which is set up on Mount Wachusett in western Massachusetts. Contact was made within a matter of seconds, and a strong, clear signal was received. The straight-line distance between units was approximately 40 miles. The portable "Microlink" is made by Raytheon Mfg. Co., Waltham, Mass.

X-rays Control Copper-strip Thickness

WATERBURY, CONN.—Automatic control of copper-alloy strip thickness is obtained by means of X-ray gauges in the mills of Chase Brass & Cooper Co., Waterbury, Conn. Visual indication of strip thickness is indicated on meter near the roll operators, which is graduated to provide readings of as little as 0.000050 inch. The X-ray gauges were designed and manufactured by Industrial Gauges Corporation of Englewood, N. J.

Western X-ray Diffraction School

SAN FRANCISCO, CALIF.—North American Philips Company, Inc., and its western dealers will hold the First Western X-ray Diffraction School at the Sir Francis Drake Hotel in San Francisco during the week of August 24-28, according to an announcement made by the Research & Control Instruments Division, 750 South Fulton Avenue, Mount Vernon, N. Y.

The week-long curriculum includes study of (1) principles, (2) applications, (3) X-ray diffraction, (4) Geiger-counter spectrometer, (5) X-ray fluorescence spectrography, (6) research. No registration fee will be charged. Those who wish to attend are urged to register as soon as possible with Philips dealers or home office; accommodations will be limited.

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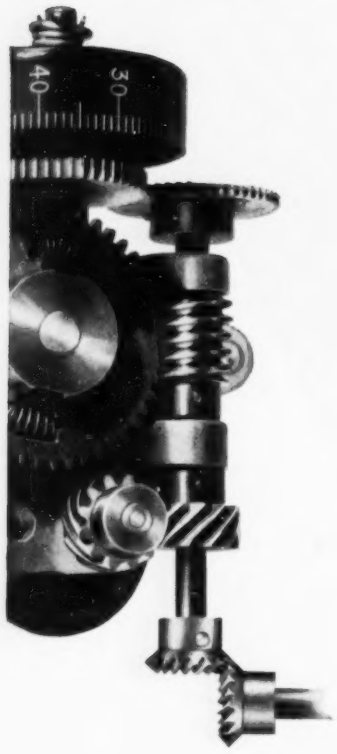

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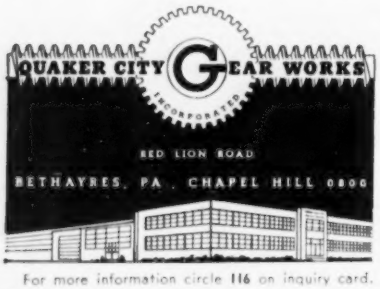

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MANUFACTURERS' NEW LITERATURE

In this department we report new literature, pertaining to instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on Page 1067.

Requests for literature FROM ABROAD should be made on company letterhead and mailed DIRECTLY to the manufacturers.

TEMPERATURE

Thermocouple Circuit Checker, Restorer. New 4-page illustrated Bulletin 100A presents principles, applications, operation, installation, and models of new "Restorer" that uses pulse of electrical energy to indicate faults in thermocouple circuits and to effect temporary cures.—The Sherman Electric Co., Inc., 1807-1809 Elm Rd., N.E., Warren, Ohio.

Circle 401 on inquiry card.

Pyrometer Controller. New 6-page Catalog Section 50 describes and illustrates maker's potentiometer signaling type "Thermo Electronic" pyrometer controller of potentiometer signaling type.—Thermo Electric Co., Inc., Fair Lawn, N.J.

Circle 402 on inquiry card.

Electric Furnaces. New 20-page catalog describes and illustrates maker's 37 electric-furnace models. Includes chart of temperature equivalent of cones, applications of pyrometer, and specifications.—L & L Mfg. Co., Chester 51, Pa.

Circle 403 on inquiry card.

Furnace & Oven Instrumentation. New 12-page illustrated Catalog P1255 presents features, operation, and specifications of maker's electronic "Dynamaster" potentiometer and millivoltmeter-type pyrometer controllers, recorders, and indicators for furnaces, ovens, dryers, and kilns.—The Bristol Co., Waterbury 20, Conn.

Circle 404 on inquiry card.

Temperature Indicators. New 2-page "Instrument News", No. 2, features article on application of maker's thermostats and fire detectors in laboratory combustion furnace, aircraft, guided missiles, etc.—Thomas A. Edison, Inc., Instrument Div., West Orange, N.J.

Circle 405 on inquiry card.

Immersion Heating Elements. New 4-page Electric Immersion Heater Catalog illustrates and describes maker's "Clepco Glorod" elements for heating acid and alkaline baths. Includes calculations for power requirements.—Cleveland Process Co., 7016 Euclid Ave., Cleveland, Ohio.

Circle 406 on inquiry card.

Temperature Control. New 2-page illustrated Bulletin 101 describes manufacturer's line of non-indicating temperature controls, covering "Models H-1S and V-1S" for use as high-temperature safety alarms and cut-outs up to 1800 deg. F.—Burlington Instrument Co., 5 Vose Ave., South Orange, N.J.

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PRESSURE, VACUUM

Pressurized Manometer. New 20-page illustrated Bulletin 28 presents principles, features, and operation of maker's pressurized manometer for measuring absolute, gage, or differential pressure to 600 inches mercury or water. Request on company letterhead to—Meriam Instrument Co., Cleveland 2, Ohio.

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Pressure Gages. New 36-page illustrated Catalog M-50 presents construction, features, and specifications of maker's large line of pressure gages. Includes Bourdon types, bellows types, pneumatic transmitters, receivers, diaphragm protectors, etc.—Acragage Corp., Milford, Conn.

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Pressure, Acceleration Pickups. New 16-page brochure presents facilities for design and manufacture of maker's scientific instruments for measurement of acceleration, pressure, force, and displacement.—Statham Laboratories, 12401 W. Olympic Blvd., Los Angeles, Calif.

Circle 410 on inquiry card.

High-vacuum Pumps, Frequency Standards. New 30-page issue no. 77 of "Cenco News Chats" features articles on testing high-vacuum pumps, frequency standards, microwave equipment, microscopes, etc.—Central Scientific Co., 1700 Irving Park Rd., Chicago, Ill.

Circle 411 on inquiry card.

WEIGHT

Weight Printer. New 2-page illustrated Brochure AM-A1 presents new "Mechanoprint" mechanical weight printer, including features, operation, and adaptations.—The Howe Scale Co., Rutland, Vt.

Circle 412 on inquiry card.

Automatic Filling Scale. New 2-page bulletin describes and illustrates maker's "Model 600 G" automatic fill-

ing scale.—Thayer Scale and Engineering Corp., East Water St., Rockland, Mass.

Circle 413 on inquiry card.

Overload Switch. New 2-page Bulletin DS-2 illustrates and describes "Dyna-Switch" for automatically stopping hoist or crane on overload.—W. C. Dillon & Co., 14620 Keswick St., Van Nuys, Calif.

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FLOW

Mass Flow Meter. New 2-page illustrated Publication TP-1-M presents principle, features, operation, and application of new "Massometer" for measuring rate of flow of materials, including dry materials, and directly calibrated in lbs. per min.—Wallace & Tiernan, Newark 1, N. J.

Circle 415 on inquiry card.

Flow Tubes. New 4-page illustrated Catalog 80 presents principles, equations, features, advantages, operation, and discharge curves for use of flow tubes in metering fluid flow.—Foster Engineering Co., Union, N. J.

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Orifice Meters. New 28-page Bulletin 1050 Rev. 1 describes and illustrates maker's "201" orifice meters. Features tables giving representative orifice capacities.—Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh, Pa.

Circle 417 on inquiry card.

Controlled-volume Pumps. New 40-page Bulletin 553 covers maker's motor-driven controlled-volume pumps. Includes 2-page chart on applications, and 4-page materials selection chart.—Milton Roy Co., Station "C", 1300 E. Mermaid Lane, Chestnut Hill, Phila., Pa.

Circle 418 on inquiry card.

Multi-tube Manometer for Flow. New 36-page Bulletin Series 410 discusses "A Multitube Differential Pressure Manometer for Measuring the Average Flow of Fluids in Closed Ducts." Price 30 cents.—Engineering Experiment Sta., University of Illinois, Urbana, Ill.

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Hot-wire Anemometer. New 2-page illustrated brochure presents features and applications of maker's hot-wire anemometer for measurement of average velocity, instantaneous velocity, or turbulence of fluid flow.—Flow Corp., 56 Kirkland St., Cambridge, Mass.

Circle 420 on inquiry card.

HUMIDITY

Moisture, Thickness Tester. New 4-page bulletin describes and illustrates German-made "Hygrotester" moisture and thickness tester for paper, textiles, and continuous processes. New 6-page bulletin gives applications and operation of "Hygrotester."—Hygrotester, Inc., 101 Henry St., P. O. Box 923, Brooklyn, N. Y.

Circle 421 on inquiry card.

Sight-flow Moisture Indicators. New 2-page illustrated release presents features, operation, and applications of maker's "Full-View" sight-flow moisture indicators that use moisture-sensitive colored particles to indicate presence of moisture in air lines.—Jacoby-Tarbox Corp., 808 Nepperhan Ave., Yonkers, N. Y.

Circle 422 on inquiry card.

Controlled Humidity. New 2-page Bulletin 112 describes and illustrates maker's controlled-humidity air-conditioning method.—Niagara Blower Co., 405 Lexington Ave., New York 17, N. Y.

Circle 423 on inquiry card.

SPEED, FREQUENCY

Tachometer Generators, Indicators. New 2-page bulletin describes and illustrates maker's "Model 104" tachometer generator; 2-page bulletin describes and illustrates maker's tachometer indicators.—The Electro-Mechano Co., Milwaukee, Wis.

Circle 424 on inquiry card.

Speed Changers. New 2-page Technical Data Sheet 3 describes and illustrates maker's "Series 3" miniature variable speed changers.—Metron Instrument Co., 432 Lincoln St., Denver, Colo.

Circle 425 on inquiry card.

CONSISTENCY, VISCOSITY

Consistency Recorder. New 2-page Data Sheet 3.6-7 describes and illustrates maker's mixer consistency recorder which measures power consumed by a mixer motor and produces a graphic record of consistency build-up.—Minneapolis-Honeywell Regulator Co., Sta. 64, Wayne & Windrim Aves., Phila., Pa.

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Recording Viscometers. New 2-page illustrated Form V1210A presents principles, features, operation, and applications of maker's recording viscometers.—Norcross Corp., 247 Newtonville Ave., Newton 58, Mass.

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Continuous Viscosity Measurement. New Instrumentation Data Sheet 10.-

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13-1a describes and illustrates "Brown Electronik" recorder and "Brookfield Viscometran" which give continuous indication and record of material's viscosity under processing conditions. —Minneapolis-Honeywell Regulator Co., Sta. 64, Wayne & Windrim Aves., Phila., Pa.

Circle 428 on inquiry card.

ANALYTICAL

X-ray Analysis. New 8-page booklet titled "Twenty Questions and Answers on X-ray Analysis" explains specimen preparation, application fields, calibration, selection of analyzing crystals, differences between powder camera and spectrometer, etc.—North American Philips Co., Research & Control Instruments Div., 750 S. Fulton Ave., Mt. Vernon, N. Y.

Circle 429 on inquiry card.

X-ray Diffraction School. New 4-page folder gives history, objectives, subjects, schedule, and lecturers for free X-ray diffraction school.—Research & Control Instruments Div., North American Philips Co., Inc., 750 South Fulton Ave., Mount Vernon, N. Y.

Circle 430 on inquiry card.

Microphotometers. New 12-page Catalog EM-90 (2) describes and illustrates maker's microphotometers for recording or indicating line-density measurements of spectrographic plates.—Leeds & Northrup Co., 4934 Stenton Ave., Phila., Pa.

Circle 431 on inquiry card.

Sulfur, Sulfide Analysis. New 4-page Bulletin CEC 1810B describes and illustrates maker's models of "Titrilog" recorder for continuous analysis of sulfur and sulfides in gases and atmospheres.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle 432 on inquiry card.

Analytical Photometer. New 8-page illustrated brochure GEC-4128 presents principles, operation, applications, and bibliography on new X-ray photometer for chemical quantitative analysis by X-ray absorption—General Electric Co., Schenectady 5, N. Y.

Circle 433 on inquiry card.

Spectrographic Analysis. New 8-page Bulletin 39 describes and illustrates maker's densitometer comparator.—Baird Associates, Inc., 1416 Massachusetts Ave., Cambridge, Mass.

Circle 434 on inquiry card.

Gas Analyzer. New 4-page illustrated bulletin presents principle of operation, typical applications, types of instruments, and specifications of maker's "Continuous Electro Conductivity" analyzer for gases or vapors that ionize either directly in water or when decomposed by heat—Davis Instruments, 47 Halleck St., Newark 4, N. J.

Circle 435 on inquiry card.

Portable Gas Analyzer. New 4-page illustrated bulletin 120 describes maker's portable gas analyzer for O_2, CO, and CO_2. Includes principles, components, and functions.—Ellison Draft Gage Co., 551 W. Monroe St., Chicago, Ill.

Circle 436 on inquiry card.

Infrared Analytical Technique. New "Perkin-Elmer Instrument News", Vol. 4, No. 3, features article on new infrared analytical technique. 2-page Product Bulletin A-3 covers infrared absorption cells.—Perkin-Elmer Corp., Norwalk, Conn.

Circle 437 on inquiry card.

Combustible-gas Alarm. New 2-page Bulletin RV453 describes and illustrates maker's scanning-type multi-point combustible-gas alarm.—Johnson-Williams, Ltd., 2613 Third St., Palo Alto, Calif.

Circle 438 on inquiry card.

Divided-circle Spectrometers. New 20-page illustrated Bulletin 157-52 lists divided-circle spectrometers and accessories of manufacturer, their applications in spectroscopy and optical manufacturing, and specifications.—Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago 14, Ill.

Circle 439 on inquiry card.

Quantometry. New Vol. 6, No. 2 issue of "Spectrographer's News Letter" features article on "New Advances in Quantometry" for continuous industrial spectrographic analysis.—Applied Research Laboratories, Glendale 5, Calif.

Circle 440 on inquiry card.

X-ray Analysis. New 22½ x 29 inch chart shows X-ray analysis curve for complex alloy (Illium) covering goniometer angular positions, curve peaks for components, and method for evaluating weak lines by magnification. —North American Philips Co., Inc., 750 S. Fulton Ave., Mt. Vernon, N. Y.

Circle 441 on inquiry card.

LABORATORY APPARATUS

Laboratory Apparatus. New 16-page illustrated 18th edition of "What's New for the Laboratory" features line of low-priced industrial balances, utility water bath, duplex heater, penetrometer, wet test meter, lab glassware washer, etc.—Scientific Glass Apparatus Co., Inc., Bloomfield, N. J.

Circle 442 on inquiry card.

Laboratory Apparatus. New 16-page catalog features complete line of heat-treating equipment, dehumidification equipment, balances, glassware, etc.—Schaar and Co., 754 W. Lexington St., Chicago 7, Ill.

Circle 443 on inquiry card.

Constant-temperature Circulator. New 2-page data sheet presents features of maker's constant-temperature circulator.—Bronwill Scientific, Inc., 40 Worth St., New York 13, N. Y.

Circle 444 on inquiry card.

Gyrotory Shaker. New 4-page bulletin describes and illustrates maker's "Model S-3 Gyrotary" shaker.—New Brunswick Scientific Co., 10 Hiram St., New Brunswick, N. J.

Circle 445 on inquiry card.

Bulletin Boards. New 2-page bulletin describes and illustrates maker's self-sealing laboratory bulletin boards. Includes description of shakers and "carbotrane."—Burrell Corp., 2223 Fifth Ave., Pittsburgh 19, Pa.

Circle 446 on inquiry card.

Laboratory Bottles. New 8-page folder describes and illustrates maker's "Stormor" flat-sided bottles. —Mallinckrodt Chemical Works, St. Louis, Mo.

Circle 447 on inquiry card.

Autoclaves. New 16-page illustrated Catalog C-118R presents features, construction, and specifications of maker's large line of laboratory sterilizers. Includes electric, steam, and gas heated models.—American Sterilizer Co., Erie, Pa.

Circle 448 on inquiry card.

OPTICAL

Optical Benches. New 28-page Bulletin 156-53 describes and illustrates maker's optical benches for testing optical systems. Includes lathe-bed type, double-rod, single-rod benches, and accessories.—The Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill.

Circle 449 on inquiry card.

Refractometer. New 4-page illustrated Brochure CH22/9 presents construction, operation, and uses of "Hilger Abbe" refractometer for liquids and solids.—The Jarrell-Ash Co., 26 Forwell St., Newtonville, Mass.

Circle 450 on inquiry card.

Phase-contrast Microscopy. New 16-page illustrated brochure D-104 describes theory, applications, and equipment used in phase-contrast microscopy in biology, chemistry, etc.—Bausch & Lomb Optical Co., Rochester 2, N. Y.

Circle 451 on inquiry card.

Machine-tool Microscope. New 2-page illustrated issue No. 0-2 of "The Perkin-Elmer Product Bulletin" presents features and operation of maker's machine-tool microscope.—The Perkin-Elmer Corp., Norwalk, Conn.

Circle 452 on inquiry card.

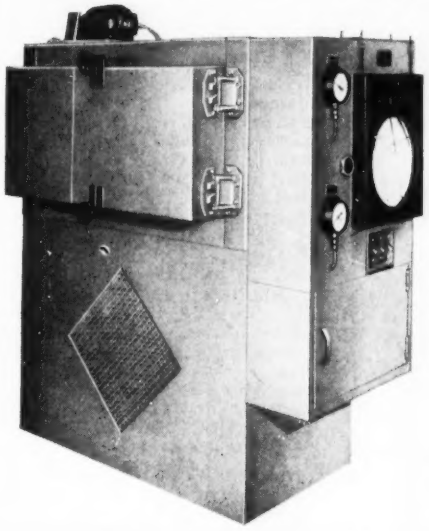
RECORDING

Oscillograph. New 2-page specifications sheet gives specifications of maker's "Model 580" multichannel recording oscillograph.—Midwestern Geophysical Laboratory, 3401 S. Harvard Ave., Tulsa, Okla.

Circle 453 on inquiry card.

Magnetic Recording System. New 4-page illustrated report PX 29678 presents characteristics of boundary-displacement magnetic-recording tech-

TEST CHAMBERS



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nique for computers, data handling, etc.—Engineering Research Associates, 1902 W. Minnehaha Ave., St. Paul, Minn.

Circle 454 on inquiry card.

Digital Tape Handler. New 2-page illustrated Bulletin A901-553 presents features and specifications of new high-speed "Models 901A and 901B" magnetic-tape handler for counting, data handling, etc.—Potter Instrument Co., Inc., 115 Cutter Mill Rd., Great Neck, N. Y.

Circle 455 on inquiry card.

Magnetic Recorder. New 2-page data sheet presents description and specifications of "Magnetic Mirragraph" multiple-channel magnetic recorder-reproducer for solution of intricate industrial problems requiring from 1 to 44 channels of data in accurate time relationship.—Techno Instrument Co., 6666 Lexington Ave., Los Angeles, Calif.

Circle 456 on inquiry card.

Tape Recorders. Two new 4-page Bulletins (AB 3-1-2 and AB 3-2-1) describe and illustrate maker's "Model 350" and "Model 450" tape recorders for sound reproduction.—Ampex Electric Corp., 934 Charter St., Redwood City, Calif.

Circle 457 on inquiry card.

COMPUTING, DATA HANDLING

General-purpose Computer. New 8-page illustrated Bulletin 116 presents general description, terminology, and operating instructions of maker's "ERA 1103" general-purpose digital-computer system.—Engineering Research Associates, 315 4th Ave., New York, N. Y.

Circle 458 on inquiry card.

Automatic Typewriter. New 12-page illustrated Form SP 8563 presents principles, features, and operation of new "Flexowriter" automatic tape-operated electric typing machine.—Commercial Controls Corp., One Leighton Ave., Rochester 2, N. Y.

Circle 459 on inquiry card.

Portable Calculator. New 4-page bulletin describes and illustrates maker's new portable (hand-sized) calculating machine for all basic mathematical operations.—Curta Calculator Co., 3851 W. Madison St., Chicago 24, Ill.

Circle 460 on inquiry card.

Computer Elements. New 40-page illustrated "File Folder" presents principles, applications, operation, and basic circuits for new "magnetic decision elements" which are basic building blocks for all digital-computing functions.—The Minnesota Electronics Corp., 47 West Water St., St. Paul, Minn.

Circle 461 on inquiry card.

Computation Center. New 12-page illustrated brochure EL-117 presents use, phases, basic equipment, features, and applications of manufacturer's computation center with "ERA 1101 Computer" for simulating and solving industrial and research problems.—Engineering Research Associates Computation Center, 555 23rd St. South, Arlington, Va.

Circle 462 on inquiry card.

Data Reduction. New Technical Bulletin No. 1 describes and illustrates maker's "OSCAR" data-reduction system for geometric solution to problem of applying nonlinear calibrations to systems. New 2-page bulletin gives specifications, prices.—Benson-Lehner Corp., 2340 Sawtelle Blvd., Los Angeles, Calif.

Circle 463 on inquiry card.

Telemetering Decommutation. New 20-page Bulletin B-12 describes and illustrates maker's "Model 525" low-pass filter decommutation system for telemetering.—Ralph M. Parsons Co., 135 W. Dayton St., Pasadena 2, Calif.

Circle 464 on inquiry card.

RADIOACTIVITY

Nuclear Counters. New 12-page illustrated Catalog 3A presents description, features, and uses of maker's electronic scalers, monitors, counters, accessories, and reactor-control instruments.—Detectolab, Inc., 6544 N. Sheridan Rd., Chicago, Ill.

Circle 465 on inquiry card.

Nuclides. New 49 x 26 inch chart of the nuclides (APH 66 C) lists elements, radiations, decays, and symbols for all chemical elements and isotopes.—General Electric Co., Schenectady 5, N. Y.

Circle 466 on inquiry card.

Count Rate Computer. New bulletin presents functions, applications, and operation of maker's "Model C-11 Count Rate Computer."—Radioactive Products, Inc., 443 W. Congress St., Detroit 26, Mich.

Circle 467 on inquiry card.

Ratemeter, Scaler. New set of four data sheets present features and specifications for maker's general purpose scaler, ratemeter, pulse amplifier, and power supplies.—Utting Associates, Inc., 290 Centre St., Newton 58, Mass.

Circle 468 on inquiry card.

TIMING, COUNTING

Electronic Counters. New illustrated 2-page and 4-page data sheets present features, descriptions, specifications, and principles of operation of manufacturer's line of high-speed electronic counting, timing, and data-handling equipment, including digital recorders, counter decades, counter-chronographs, and frequency-time counters.—Potter Instrument Co., Inc., 115 Cutter Mill Rd., Great Neck, N. Y.

Circle 469 on inquiry card.

Time Calibrators. New 2-page bulletin describes and illustrates maker's

time calibrators for oscilloscope sweep calibration. 2-page bulletin presents "Type 200" low-voltage power supply. —Owen Laboratories, 412 Woodward Blvd., Pasadena 10, Calif.

Circle 470 on inquiry card.

Stop-watches. New 12-page bulletin describes and illustrates maker's stop-watches, chronographs and multi-purpose watches.—Wakman Watch Co., Inc., 15 West 47 St., New York, N. Y.

Circle 471 on inquiry card.

SERVO SYSTEMS, PARTS

Servo Motors. New 20-page illustrated catalog presents features and specifications of maker's line of miniaturized control motors, including damped and hysteresis synchronous types. Includes load characteristics for use in computers, servosystems, etc.—Servomechanisms, Inc., Westburg, N. Y.

Circle 472 on inquiry card.

Servo Motors. New 2-page illustrated Form 2395 presents features and specifications of maker's "Type 665-50" miniature AC precision motors for servo and control use; 2-page Form 2403 covers "Type 665-51."—G-M Laboratories, Inc., 4300 North Knox Ave., Chicago 41, Ill.

Circle 473 on inquiry card.

Servo Systems. New 4-page Engineering Bulletin discusses servo fundamentals as related to hydraulic control field. Discusses pressure-control versus flow control in design of high-performance hydraulic servo fundamentals.—Standard Controls, Inc., 1230 Poplar Pl., Seattle, Wash.

Circle 474 on inquiry card.

Gears, Gear Trains. New 4-page illustrated brochure presents maker's precision gears and gear trains for electromechanical devices and servo equipment. Includes dimensions, specifications.—Bowmar Instrument Corp., Smith Municipal Airport, Fort Wayne, Ind.

Circle 475 on inquiry card.

Synchro Tester. New 2-page bulletin describes and illustrates maker's "Type 226" synchro error tester for production testing. Includes test equipment listing. 2-page bulletin gives vector impedance locus plotter, bridge null indicator, and aging rack. —Pennsylvania Testing Laboratory, Doylestown, Pa.

Circle 476 on inquiry card.

Servo Amplifier. New 4-page bulletin describes and illustrates maker's "Model 434-B" servo amplifier.—Industrial Control Co., Wyandanch, L. I., N. Y.

Circle 477 on inquiry card.

PROCESS INSTRUMENTATION

Process Instrumentation. New 23-page issue of "Taylor Technology" (Vol. 5, No. 4) describes maker's process instruments in use in articles on

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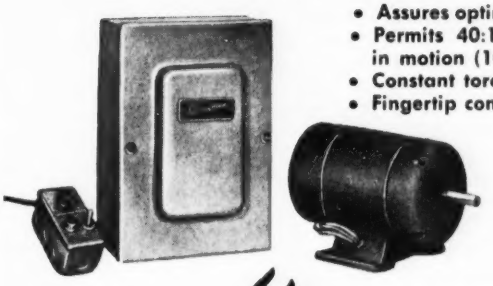

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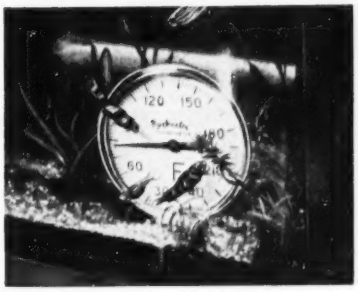

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NEW LITERATURE

drug manufacturing, ocean-depth probing, atomic energy plant at Oak Ridge, and others.—Taylor Instrument Companies, Rochester 1, N. Y.

Circle 478 on inquiry card.

Process Instrumentation. New 40-page issue of "Instrumentation", (Vol. 6, No. 5) describes and illustrates maker's process instruments in use in acticles on guided missiles, bearing manufacturing, steel, and others.—Minneapolis-Honeywell Regulator Co., Wayne & Windrum Aves., Phila., Pa.

Circle 479 on inquiry card.

Process Control. New 16-page Bulletin 18 gives information on maker's complete line of instruments for measurement and control applications in power plants, process industries, etc. —Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

Circle 480 on inquiry card.

Process Instrumentation. New 4-page issue of "Wheelco Comments" (Vol. 13, No. 1) features article on maker's process instruments in use at Buffalo Perlite Corp., N. Y.—Wheelco Instruments Div., Barber-Colman Co., Rockford, Ill.

Circle 481 on inquiry card.

Recorder-Controller. New 4-page illustrated Bulletin TI 33-A-15a, describes combinations of control and alarm available with "Multi-record Dynalog Recorder."—The Foxboro Co., Foxboro, Mass.

Circle 482 on inquiry card.

Remote Level Gaging. New 16-page Bulletin VG-353 describes and illustrates maker's "Varioplex" remote level-gaging system.—Shand & Jurs Co., 8th & Carlton Sts., Berkeley, Calif.

Circle 483 on inquiry card.

VALVES

Control Valves. New 44-page Catalog CV53 describes and illustrates maker's automatic control valves. Includes bodies, trim, inner valves, characteristics, features, types, bellows seal, positioners, etc.—Kieley & Mueller, Inc., Middletown, N. Y.

Circle 484 on inquiry card.

Sequence Valve. New 2-page illustrated Bulletin 4812 presents features, operation, and specifications of maker's "Model SQ" sequence valve for control of multi-operations.—Airmatic Valve, Inc., 7317 Associate Ave., Cleveland, Ohio.

Circle 485 on inquiry card.

Lubricated Plug Valves. New 32-page illustrated Catalog 180 presents maker's new line of lubricated plug valves, dimensions, list prices, accessories, and ratings.—Ohio Injector Co., Wadsworth, Ohio.

Circle 486 on inquiry card.

Valves, Solenoids. New 14-page illustrated catalog presents products, personnel, and facilities of manufacturer of check valves, solenoids, and pneumatic and hydraulic control equipment.—Carruthers & Fernandez, Inc., 1501 Colorado Ave., Santa Monica, Calif.

Circle 487 on inquiry card.

COMMUNICATION, TV

Carrier-system Filters. New 8-page issue Vol. 2 No. 6 of "Lenkurt Demodulator" features article on factors involved in design of carrier-system filters. —Lenkurt Electric Co. San Carlos, Calif.

Circle 488 on inquiry card.

Microwave Equipment. New 32-page illustrated catalog presents maker's line of electronic equipment—multipurpose X-band test sets, radar equipment, and microwave testing sets—with features and specifications.—Century Electronics, 14806 Oxnard St., Van Nuys, Calif.

Circle 489 on inquiry card.

TV Frequency Monitor. New 4-page illustrated Vol. 4 No. 9-10 issue of "hp Journal" presents circuit arrangements, diagrams, construction, and measurements of maker's "Model 335B" FM frequency monitor and modulation meter.—Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.

Circle 490 on inquiry card.

RECTIFIERS, SUPPLIES

Rectifier Power Supplies. New 16-page illustrated booklet GEC-970 describes applications and operation of maker's line of manually-controlled and automatically regulated metallic-rectifier power supplies; lists ratings, dimensions, and specifications.—General Electric Co., Schenectady 5, N. Y.
Circle **491** on inquiry card.

Selenium Rectifiers. New 4-page issue RN-453 of "International Rectifier News" features article on maker's selenium rectifiers. Companion Bulletin GD-1 covers maker's germanium diodes.—International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.
Circle **492** on inquiry card.

Miniature Selenium-rectifier Stacks. New 4-page Bulletin GEA-5935 gives applications, features, electrical characteristics, ratings table, etc. of maker's small selenium rectifier.—General Electric Co., Schenectady 5, N. Y.
Circle **493** on inquiry card.

Regulated Power Supplies. New 8-page illustrated bulletin presents maker's high- and low-voltage magnetic-amplifier-regulated power supplies.—Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.
Circle **494** on inquiry card.

Power Supplies. New 28-page illustrated catalog presents features and specifications of line of regulated power supplies.—Kepco Labs, Inc., 131 Sanford Ave., Flushing, N. Y.
Circle **495** on inquiry card.

MAGNETS, MATERIALS

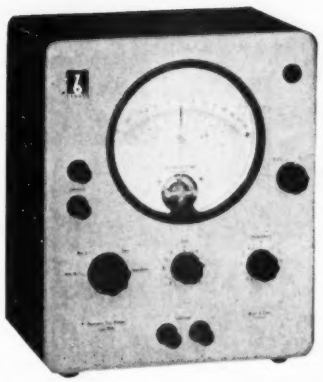
Permanent Magnets. New bi-monthly technical house organ, "Applied Magnetics", presents information useful to engineers, production men, and purchasing agents using permanent magnets. First issue (Vol. 1 No. 1) contains article on "Introduction to the Design of Permanent Magnets."—Indiana Steel Products Co., Dept. A-M, Valparaiso, Ind.
Circle **496** on inquiry card.

Magnetic Iron Powders. New 8-page Catalog 354 describes and illustrates uses and applications of magnetic iron powders.—Magnetic Powders, Inc., Johnsonburg, Pa.
Circle **497** on inquiry card.

ELECTRICAL INSTRUMENTS

Demand Meters. New 48-page Manual GET-2327 describes theory, economics, operation, and application of demand meters. Includes principles and problems of demand metering, and reference for specific demand-measuring application.—General Electric Co., Schenectady 5, N. Y.
Circle **498** on inquiry card.

Ruggedized Meters. New 4-page Bulletin RM 4523 describes and illustrates maker's shockproof hermetically-sealed meters.—The Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland 8, Ohio.
Circle **499** on inquiry card.



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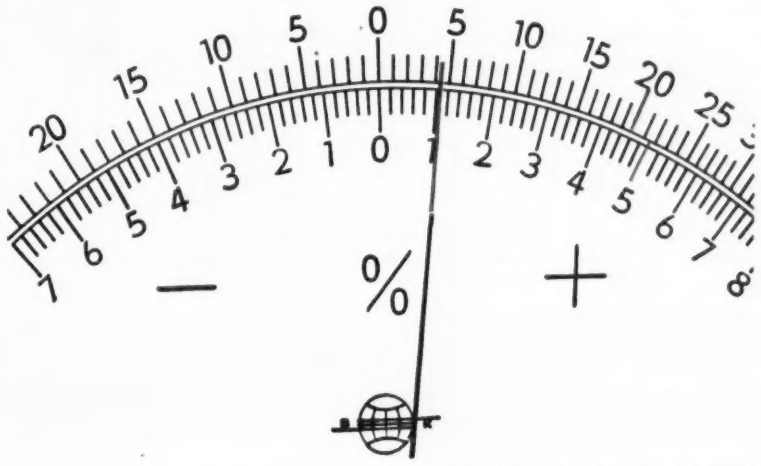

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The Brush Development Co.
Brush Electronics Company is an operating unit of Clevite Corporation.

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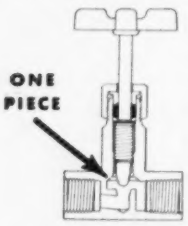
Needle Valves

MAXIMUM WORKING PRESSURE 10,000 PSI

. . . for finer regulation of water, oil or gas

First needle valve to combine all the characteristics called for in modern industry. Embodies sturdiest basic construction—machined from solid bar stock—suitable for pressures to 10,000 psi and equally efficient in lower range. Note stem guide fused to body by new "Conoweld" process, eliminating faults of conventional two-piece valves. Stem 416 stainless steel. Stem threads fine pitch for strength and micrometer regulation. Body electro-zinc plated. Sizes ⅛" to 1", globe and angle patterns.



Ask for new Needle Valve Catalog

MARSH INSTRUMENT CO. *Sales affiliate of Jas. P. Marsh Corporation*
Dept. 42, Skokie, Ill.

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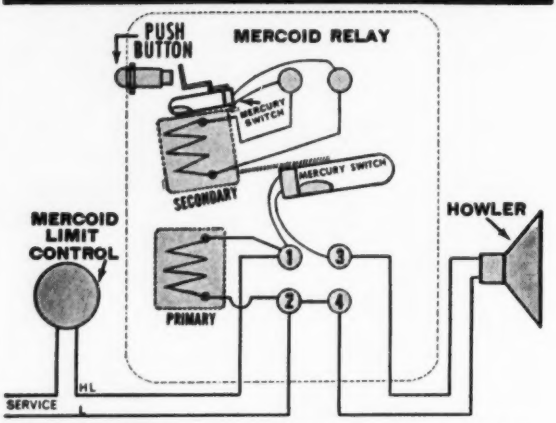
MERCOID RELAY FOR AUDIBLE ALARM



When Limit Control closes its circuit, current is supplied to primary coil of Mercoid Relay and through the normally closed mercury switch to the "Howler" (alarm). To stop "Howler," operator pushes in "push button" which manually raises relay secondary and breaks circuit to "Howler." Secondary is held up by magnetic repulsion until condition is corrected. When limit control opens the primary circuit of relay, secondary coil drops to normal position and relay is automatically ready for another operation.

WRITE FOR BULLETIN CA-8R

THE MERCOID CORPORATION, 4201 BELMONT AVE., CHICAGO, ILL.

For more information circle **135** on inquiry card.

NEW LITERATURE

Panel Instruments. New 6-page illustrated bulletin presents specifications, features, and prices of maker's line of panel instruments—ammeters, galvanometers, voltmeters, and plug-in meters.—Cole Instrument Co., 1320 S. Grand Ave., Los Angeles, Calif.

Circle **500** on inquiry card.

Wattmeters. New 8-page illustrated issue Vol. 20 No. 4 of "Electrical Measurements" presents features of manufacturer's line of wattmeters.—Sensitive Research Instrument Corp., 9 Elm Ave., Mt. Vernon, N.Y.

Circle **501** on inquiry card.

Ruggedized Electrical Indicators. New 4-page Bulletin PM2 describes and illustrates maker's ruggedized, glass-to-metal hermetically sealed, electrical indicating instruments.—Phaostron Co., 151 Pasadena Ave., South Pasadena, Calif.

Circle **502** on inquiry card.

TESTING, INSPECTION

Testing Equipment. New 8-page issue of "Testing Topics" features articles on development of an instrument to test creep characteristics of steel wire under tension; how to make a bonded electric resistance strain gage with mercury for use on materials of high stretch; expediting accumulated test data from analogs to figures, and picture story on how to design casting by use of stress-analyzing methods.—Baldwin-Lima-Hamilton Corp., Phila. 42, Pa.

Circle **503** on inquiry card.

Portable Strain Indicator. New 2-page illustrated Bulletin 4103 describes newly improved SR-4 portable strain indicator, with self-contained a-c. power pack mounted inside instrument case.—Baldwin-Lima-Hamilton Corp., Phila. 42, Pa.

Circle **504** on inquiry card.

Universal Testing Machine. New 22-page Bulletin 47 describes and illustrates maker's lines of "Super L" universal testing machines.—Tinius Olsen Testing Machine Co., Easton Road, Willow Grove, Pa.

Circle **505** on inquiry card.

Vibration Testing Machines. New illustrated 8-page Bulletin 6405 presents features, specifications, and ordering information for manufacturer's intermediate shaker systems to 1250-pound force output; 4-page Bulletin 4805 covers larger system of 2500-pound force output.—Calidyne Co., Winchester, Mass.

Circle **506** on inquiry card.

Environmental Test Equipment. New 4-page bulletin describes and illustrates maker's line of environmental test chambers.—American Research Corp., 11 Brook St., Bristol, Conn.

Circle **507** on inquiry card.

Soil-testing Apparatus. New 72-page illustrated Catalog 53 presents manufacturer's line of over 800 items for engineering tests of soils, concrete, and bituminous materials and general laboratory apparatus.—Soiltest, Inc., 4520 W. North Ave., Chicago 39, Ill.

Circle **508** on inquiry card.

Surface Roughness Measurement. New 8-page Bulletin LT77 describes and illustrates maker's "Profilometer" for measuring surface roughness.—Micrometrical Mfg. Co., 345 S. Main St., Ann Arbor, Mich.

Circle **509** on inquiry card.

Surface Roughness. New illustrated data sheet Form LT76 presents new "Type KB" tracer for "Profilometer" measurements across bottom of grooves and over shoulders. Includes features and specifications.—Micrometrical Mfg. Co., 345 S. Main St., Ann Arbor, Mich.

Circle **510** on inquiry card.

Internal Inspection. New 12-page folder describes and illustrates maker's "Borescopes" for visual internal inspection.—Lenox Instrument Co., 2012 Chancellor St., Phila. 3, Pa.

Circle **511** on inquiry card.

Fibre-length Tester. New 4-page illustrated brochure presents principle, features, and operation of new motor-driven "Servo-Fibrograph" for rapid testing of fiber length.—Spinlab Laboratories, 1003 Highland Ave., Knoxville, Tenn.

Circle **512** on inquiry card.

ELECTRICAL & ELECTRONIC TEST EQUIPMENT

Insulation-resistance Testing. New 50-page manual gives practical insulation-resistance testing using "Vibrotest" insulation-resistance testing instruments. Free to "Vibrotest" owners. Fifty cents to others.—Associated Research, Inc., 3758 W. Belmont Ave., Chicago 18, Ill.
Circle 513 on inquiry card.

VTVM. New 4-page illustrated bulletin presents description, specifications, and prices of maker's vacuum-tube voltmeter, regulated power supply, and thermocouple gauge control circuit for vacuum measurement. Scientific Specialties Corp., Snow & Union Sts., Boston 35, Mass.
Circle 514 on inquiry card.

Microwave Spectrum Analyzer. New 4-page Bulletin SA20-3-1 describes and illustrates maker's microwave spectrum analyzers. Includes price sheet.—Vectron, Inc., 400 Main St., Waltham, Mass.
Circle 515 on inquiry card.

Wavemeter. New 4-page bulletin describes and illustrates maker's wavemeter for frequency and relative-power measurements from 2400-3400 Mc. —Electronics Div., American Encaustic Tiling Co., Lansdale, Pa.
Circle 516 on inquiry card.

Pipeline Flaw Detector. Three new 2-page bulletins describe and illustrate maker's models of wrapped-pipeline flaw detectors. Includes information on "Model H-2" that operates without ground wire.—Tinker & Rasor, P.O. Box 281, San Gabriel, Calif.
Circle 517 on inquiry card.

Electric Test Equipment. New 4-page booklet describes service and equipment available from instrument distributor.—Electro Tech Equipment Co., 308 Canal St., New York 13, N.Y.
Circle 518 on inquiry card.

Oscilloscope. New release illustrates and describes maker's new oscilloscope (5-Mc. vertical amplifier) in kit and wired form. Includes specifications.—Precise Development Corp., 999 Long Beach Rd., Oceanside, L.I., N.Y.
Circle 519 on inquiry card.

Hum Stethoscope. New 20-page issue of "Cornell-Dubilier Capacitor" (Vol. 18, No. 4) features article on hum stethoscope for amplifier troubleshooting.—Cornell-Dubilier Electric Corp., Hamilton Blvd., South Plainfield, N.J.
Circle 520 on inquiry card.

Circuit Tracer. New 2-page bulletin and 6-page folder describe and illustrate maker's "Circuitracer" for circuit continuity up to 600 volts.—Delta Electrical Specialty Co., 1456 E. Walnut St., Pasadena, Calif.
Circle 521 on inquiry card.

Insulation Tester, Oscilloscope. New 2-page bulletin describes and illustrates maker's "Model K" insulation tester for evaluation of high-voltage components and materials. 2-page bul-

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One of many Bendix-Friez precision instruments that are solving many important problems for industry.

This finely-precisioned instrument provides a continuous, accurate, *electrically-written* record of wind direction and velocity. It offers you the *scientific* way to get data that's indispensable for working out smoke and fume control most effectively. Every day Bendix-Friez weather instruments . . . the accepted standard of comparison . . . are proving that they can perform more and more valuable services for industry. Let us demonstrate how we can help you. *REG. U.S. PAT. OFF.

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FOR LINEAR CONVERSION OF WEIGHT INTO POUNDS PER SQUARE INCH AIR PRESSURE

A complete line of weight transmitters in single and multiple diaphragm construction with load capacities up to 23,000 pounds per diaphragm. Pneumatic tare balance for any portion of the total load on all models. All moving parts are enclosed totally. Complete weighing systems designed to your requirements.

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Manufacturing Engineer
Pitman, N. J.

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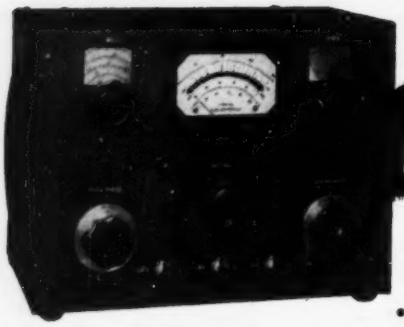

NEW DEVELOPMENT in

VHF measurements

Q-METER *TYPE 190-A*

17 YEARS OF RESEARCH PRODUCED THESE IMPORTANT FEATURES

- Single, easy-to-read meter, with parallax correction, for all functions.
- Q indicating voltmeter: 50 to 400.
- Multiply Q scale: 0.5 to 3.0.
- A differential Q scale for accurately indicating the difference in Q between two test circuits.
- Additional accurate expanded scale for measuring low values of Q.
- A counter type resonating capacitor dial for improving setting and reading accuracy.
- Careful design to minimize instrument loading of circuit under test.
- Low internal inductance, capacitance and resistance.
- Regulated power supply for increased stability and accuracy.
- Tunable oscillator in four ranges calibrated to high accuracy.
- Compact, simple, rugged construction.

This new 190-A Q Meter measures an essential figure of merit of fundamental components to better overall accuracy than has been previously possible. The VTVM, which measures the Q voltage at resonance, has a higher impedance. Loading of the test component by the Q Meter and the minimum capacitance and inductance have been kept very low.

SPECIFICATIONS—TYPE 190-A

FREQUENCY RANGE: 20 mc. to 260 mc.

RANGE OF Q MEASUREMENT:

Q indicating voltmeter	50 to 400
Low Q scale	10 to 100
Multiply Q scale	0.5 to 3.0
Differential Q scale	0 to 100
Total Q indicating range	5 to 1200

PERFORMANCE CHARACTERISTICS OF INTERNAL RESONATING CAPACITANCE: Range — 7 mmfd. to 100 mmfd. (direct reading).

POWER SUPPLY: 90-130 volts — 60 cps (internally regulated).

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AIRCRAFT INSTRUMENTS ENGINEER

Excellent position for engineering graduate with several years' experience in diaphragm aircraft instrument design. This is a position with a progressive organization. Please direct replies directly to The Lackner Company, Inc., attention Mr. E. L. Kane, 1115 York Street, Cincinnati 14, Ohio.

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INSTRUMENT MECHANICS WANTED

The Tennessee Valley Authority wants experienced instrument mechanics for work in chemical plants at Wilson Dam, Alabama. The work is inspecting, testing, repairing, adjusting, and calibrating service instruments, including actuating connections and control equipment. Instruments are electrical, mechanical, pneumatic, hydraulic, thermal, or any combination of these. Salary is $4500 per year for 40-hour week. Liberal vacation leave, sick leave, and retirement benefits.

Write to the

TENNESSEE VALLEY AUTHORITY

Division of Personnel
Knoxville, Tennessee

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Engineer -- Instrument Designer

Excellent opportunity for a graduate mechanical engineer, with at least 10 years of practical instrument designing experience.

Position eventually will develop into Chief Engineer.

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Please give complete history of your education, background, and salary expected, also enclose photo if possible.

All replies will be answered and held confidential.

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845 Ridge Ave., Pittsburgh 12, Pa.

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NEW LITERATURE

letin describes and illustrates maker's "Model S-5" 5-inch rack-mounted basic oscilloscope.—Tinker & Rasor, P. O. Box 281, San Gabriel, Calif.

Circle 522 on inquiry card.

TRANSISTORS, TUBES, DIODES

Electron Tubes. New 24-page catalog presents condensed data on maker's tubes for communication, industrial uses, rectification, radiation detection, electro-medical purposes, amateur, and special uses.—Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L. I., N. Y.

Circle 523 on inquiry card.

Electron-tube Construction. New 16-page illustrated booklet TBP-1 shows structural details of electron tubes of all types.—Commercial Engineering, RCA Tube Dept., Harrison, N.J.

Circle 524 on inquiry card.

Transistors. New 4-page illustrated bulletin presents manufacturer's new line of transistors, specifications, and production facilities. Single data sheet presents specifications of switching transistor Type T-1.—Hydro-Aire, Inc. 3000 Winona Ave., Burbank, Calif.

Circle 525 on inquiry card.

Ballast Regulators. New 4-page illustrated Bulletin AB-51 provides description, specifications, and characteristics of maker's ballast regulating tubes.—Amperite Co., Inc., 561 Broadway, New York 12, N.Y.

Circle 526 on inquiry card.

UHF Tubes. New 16-page Bulletin 5-1-53-10M describes and illustrates maker's tubes for UHF.—Sylvania Electric Products, Inc., 1740 Broadway, N.Y., N.Y.

Circle 527 on inquiry card.

Temperature-limited Diodes. New 4-page folder gives specifications for six temperature-limited diodes having stable emission characteristics.—Thermosen, Inc., 361 W. Main St., Stamford, Conn.

Circle 528 on inquiry card.

Silicon Diodes. New 4-page Catalog 53 S describes and illustrates maker's silicon diodes for microwave mixer and video use. Includes distribution charts and tables for diodes for use from 10 to less than 1 cm.—Microwave Associates, Inc., 22 Cummington St., Boston, Mass.

Circle 529 on inquiry card.

Picture-tube Data Chart. New eighth edition of picture-tube data chart, suitable for wall hanging, lists complete specifications for more than 150 picture tubes of all manufacturers.—Allen B. DuMont Laboratories, Inc., 1500 Main Ave., Clifton, N.J.

Circle 530 on inquiry card.

Germanium Diodes. New 2-page bulletin describes and illustrates maker's germanium diodes.—Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L.I., N.Y.

Circle 531 on inquiry card.

Germanium Diode. New 4-page bulletin describes and illustrates maker's fusion-sealed-in-glass subminiature germanium diode.—Huges Aircraft Co., Culver City, Calif.

Circle **532** on inquiry card.

RESISTORS, POTENTIOMETERS

Wire-wound Resistors. New 12-page illustrated Catalog 14-Rb presents mechanical specifications, descriptions, and ordering information for manufacturer's precision non-inductive fixed wire-wound resistors. Folder C-1024 describes maker's new CE resistors featuring hermetically-sealed protection, increased temperature range. and less internal strain.—Cinema Engineering Co., 1510 W. Verdugo Ave., Burbank, Calif.

Circle **533** on inquiry card.

Resistors, Magnetic Cores. New 20-page illustrated catalog presents features, specifications, and color codes for maker's large line of fixed composition resistors, molded winding forms, iron coil forms, iron cores, and iron sleeve and cup cores.—Speer Carbon Co., St. Marys, Pa.

Circle **534** on inquiry card.

Wire-wound Resistors. New 12-page illustrated Bulletin C-1 presents data on features, characteristics, and specifications for manufacturer's tubular and flatpower wire-wound resistors.—International Resistance Co., 401 N. Broad St., Phila., Pa.

Circle **535** on inquiry card.

Potentiometers. New 2-page illustrated Bulletin 107-A presents specifications, design features, and modifications of maker's "Universal Potentiometer Model 85196."—G. M. Giannini & Co., Inc., 332 Springfield Ave., Summit, N.J.

Circle **536** on inquiry card.

Potentiometers. New 2-page Bulletin 101-A presents features and specifications for maker's slide-wire multi-turn potentiometer.—G. M. Giannini & Co., Inc., 332 Springfield Ave., Summit, N. J.

Circle **537** on inquiry card.

Resistors. New 16-page illustrated catalog contains Bulletins 11001 through 11012 and presents description, features, and dimensions of maker's general-purpose resistors—power, unit tape, "Dur-ristor" boxes, etc.—Cutler-Hammer, Inc., 315 N. 12 St., Milwaukee 1, Wis.

Circle **538** on inquiry card.

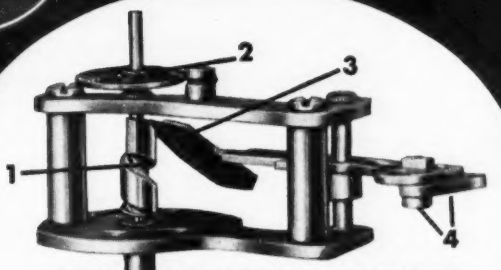
Resistor. New 2-page bulletin describes and illustrates maker's "Model 7" resistor.—Rochester Electronics Co., Inc., P.O. Box 227, Penfield, N. Y.

Circle **539** on inquiry card.

Molded Precision Resistors. New 4-page illustrated issue No. 120 of "Sprague Engineering Bulletin" presents construction, features, and performance characteristics of maker's "Durameg" molded precision wire-

ACCO products

HELICOID GAGES



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3. Long Life Cam (no gear teeth)
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• HELICOID is the greatest achievement of the gage makers' craft—the pressure or vacuum gage *without gears... without teeth!* The HELICOID movement is a simple cam and roller device that gives long, trouble-free service. It has been tested and proved in years of hard service in the field.

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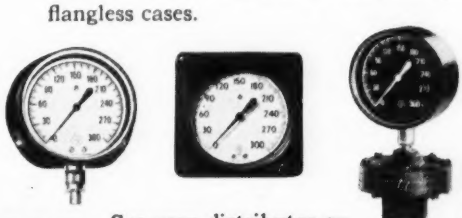
You can get HELICOID Gages for pressure, vacuum, or compound service—in all pressure ranges; white, black, or radiant faces; wall, stem, flush, and panel mountings, or flangless cases.



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wound resistors.—Sprague Electric Co., North Adams, Mass.

Circle 540 on inquiry card.

CAPACITORS

Pulse-forming Networks, Capacitors. New 28-page illustrated brochure provides design and test data on "Capitron" capacitors and pulse-forming networks.—Aircraft-Marine Products, Inc., 2100 Paxton St., Harrisburg, Pa.

Circle 541 on inquiry card.

Paper Capacitors. New 4-page illustrated Bulletin AB-19 presents performance characteristics and test specifications on maker's high-temperature metallized paper capacitors.—Astron Corp., 255 Grant Ave., E. Newark, N. J.

Circle 542 on inquiry card.

Capacitors. New 24-page Bulletin 50 describes and illustrates maker's large line of variable and fixed air capacitors.—The Allen D. Cardwell Mfg. Corp., Plainville, Conn.

Circle 543 on inquiry card.

Plastic Capacitors. New 4-page Bulletin AB-20A gives performance characteristics and test specifications of maker's "Blue-point" molded plastic capacitors.—Astron Corp., 255 Grant Ave., East Newark, N. J.

Circle 544 on inquiry card.

Subminiature Paper Capacitors. New 4-page Bulletin AB-18 gives performance characteristics and test specifications of maker's "Meteor" high-temperature subminiature paper capacitors.—Astron Corp., 255 Grant Ave., East Newark, N. J.

Circle 545 on inquiry card.

TRANSFORMERS, REACTORS

Coils, Capacitors. New 44-page catalog describes and illustrates maker's capacitors, coils, and insulators.—Jeffers Electronics, Div. Speer Carbon Co., DuBois, Pa.

Circle 546 on inquiry card.

Transformers, Reactors, Filters. New 24-page Catalog 530 describes and illustrates maker's large line of transformers, reactors. linear standard power equipment, hermetically sealed components, audio components, etc.—United Transformer Co., 150 Varick St., New York, N. Y.

Circle 547 on inquiry card.

Controllable Inductors. New set of four 4-page brochures illustrate and describe maker's "Increductor" unit which adjusts inductance value by means of current. Includes diagrams, applications, specifications, and nomenclature.—C.G.S. Laboratories, Inc., 391 Ludlow St., Stamford, Conn.

Circle 548 on inquiry card.

Transformers. New 20-page illustrated brochure presents facilities of manufacturer for transformers of all types. 2-page data sheet presents features, construction, and specifications transformers.—Gramer Transformer Corp., 2734 N. Pulaski Rd., Chicago, Ill.

Circle 549 on inquiry card.

Autotransformers. New 8-page issue Vol. 27 No. 12 of "General Radio Experimenter" features article on "Variac" adjustable autotransformer, and "Type 1551-P1" condenser-microphone system.—General Radio Co., Cambridge, Mass.

Circle 550 on inquiry card.

Autotransformer. New 12-page illustrated Catalog 424M presents features, construction, and specifications of maker's continuously adjustable "Variac" autotransformer.—General Radio Co., 275 Massachusetts Ave., Cambridge, Mass.

Circle 551 on inquiry card.

RELAYS, SWITCHES

Relays. New 2-page issue No. 2 of "Relay Highlights" describes and illustrates maker's "Class S" heavy-duty relays.—Automatic Electric Sales Corp., 1033 W. Van Buren St., Chicago 7, Ill.

Circle 552 on inquiry card.

Thermostatic Delay Relay. New 4-page bulletin TR-81 presents specifications, performance information, and order information for maker's thermostatic delay relays.—Amperite Co., Inc., 561 Broadway, New York 12, N. Y.

Circle 553 on inquiry card.

Mercury Plunger Relays. New 4-page bulletin describes and illustrates maker's mercury plunger relays.—Ebert Electronics Co., 212 Jamaica Ave., Queens Village, L. I., N. Y.

Circle 554 on inquiry card.

Circuit Breakers. New Booklet B-5456 describes and illustrates maker's "AB-1" circuit breakers.—Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.

Circle 555 on inquiry card.

ELECTRICAL & ELECTRONIC COMPONENTS

Electronic Components. New 58-page Catalog 553 describes and illustrates more than 2200 items—capacitors, resistors, batteries, rectifiers, etc.—P. R. Mallory & Co., Inc., 3029 E. Washington St., Indianapolis, Ind.

Circle 556 on inquiry card.

Photo Etching, Plated Circuitry. New 12-page bulletin presents advantages and facilities for producing electronic components and circuits by photo-wiring, -forming, -etching, and plated circuitry. 4-page brochure describes and illustrates maker's UHF converter tuner.—The Allen D. Cardwell Mfg. Corp., 50 Gleason St., Stamford, Conn.

Circle 557 on inquiry card.

Small Motor Switches. New 12-page illustrated Bulletin 8000 B-2 lists maker's small motor switches (toggle, rotary, etc.), specifications, and features.—Cutler-Hammer, Inc., Milwaukee 1, Wis.

Circle 558 on inquiry card.

Electric Motors. New 4-page issue (Vol. 33 No. 3) of "Motorgram" describes methods of testing load-bearing capacity of soil and gives advantages of motors with built-in speed reducers.—Bodine Electric Co., 2250 W. Ohio St., Chicago 12, Ill.

Circle 559 on inquiry card.

Electronic Components. New 4-page bulletin presents maker's line of electronic components, including tubes, capacitors, antennas, transformers, relays, coaxial cable, etc.—Lectronic Research Labs, 715 Arch St., Phila. 6, Pa.

Circle 560 on inquiry card.

TV Fuse Guide. New booklet presents information on fuse useage in modern television sets for manufacturers, jobbers, and service men.—Littelfuse, Inc., 1865 Miner St., Des Plaines, Ill.

Circle 561 on inquiry card.

Slip-ring Assemblies, Commutators. New 4-page illustrated bulletin presents production techniques and features of maker's precision slip-ring assemblies and commutators.—Electro Tec Corp., S. Hackensack, N. J.

Circle 562 on inquiry card.

Delay Lines. New 4-page bulletin describes and illustrates maker's solid ultrasonic delay lines for memory and storage devices, MTI, etc.—Anderson Laboratories Inc., West Hartford, Conn.

Circle 563 on inquiry card.

Electrical Connectors. New 12-page Bulletin 3-4-1 describes and illustrates maker's line of electrical connectors, including firewall, feedthrough, and cable types.—AiResearch Mfg. Co., Los Angeles, Calif.

Circle 564 on inquiry card.

Connectors, Components. New 48-page illustrated Catalog B2 presents features, construction, and specifications of maker's antennas, connectors, plugs, sockets, transmission lines, etc.—American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.

Circle 565 on inquiry card.

Electrical Wiring Devices. New 26-page Catalog 12 covers maker's line of wiring devices for fluorescent, incandescent, maritime, and display application; 20-page Catalog 14 covers line of terminal blocks, lugs, spreaders, etc.—Kulka Electric Mfg. Co., Inc., 633 S. Fulton Ave., Mt. Vernon, N. Y.

Circle 566 on inquiry card.

Electronic Components. New 16-page illustrated catalog presents distributor's lines of relays, switches, rectifiers, motors, and electronic components.—Herbach & Rademan, Inc., 1204 Arch St., Phila., Pa.

Circle 567 on inquiry card.

TUBING FITTINGS

Tubing Fittings. New 17 x 22 inch wall chart illustrates maker's "Swagelok" fittings.—Crawford Fitting Co., 884 East 140 St., Cleveland, Ohio.

Circle **568** on inquiry card.

Couplings. New 34-page bulletin describes and illustrates maker's quick-disconnect couplings for electrical, electronic, and mechanical applications.—Hallett Mfg. Co., 1601 Florence Ave., Inglewood, Calif.

Circle **569** on inquiry card.

SHOP EQUIPMENT

Soldering Irons. New 8-page illustrated Catalog GEA-4519D presents features, construction, and applications of large line of soldering irons. Includes flux chart.—General Electric Co., Schenectady 5, N. Y.

Circle **570** on inquiry card.

Soldering, Brazing Paste Alloys. New 8-page illustrated reprint discusses soldering and brazing with paste alloys. New 2-page Bulletin INS 53 discusses maker's fusion paste alloys for soldering and silver brazing. —Fusion Engineering, 4504 Superior Ave., Cleveland, Ohio.

Circle **571** on inquiry card.

Precision Tools. New 32-page indexed and illustrated Catalog L presents features construction, and specifications of maker's large line of calipers, centers, chucks, drill presses, grinders, lathes, etc.—Louis Levin & Son, Inc., 782 E. Pico Blvd., Los Angeles, Calif.

Circle **572** on inquiry card.

Flexible-shaft Controls. New 28-page illustrated catalog, "Guide to Selection and Application of Arens Push-Pull Controls" presents practical engineering data, application factors, blueprints, and illustrations of maker's flexible-shaft control models.—Arens Controls, Inc. 2017 Greenleaf St., Evanston, Ill.

Circle **573** on inquiry card.

Labels. New 2-page bulletin describes and illustrates maker's smudge-proof write-on labels.—Label-on Tape Co., Inc., 450 Atlantic Ave., Rochester, N. Y.

Circle **574** on inquiry card.

Fly Cutter. New 4-page bulletin describes and illustrates maker's "No. 800" and "No. 801" fly cutter and round-shank fly cutter, respectively.—Mico Instrument Co., 80 Trowbridge St., Cambridge, Mass.

Circle **575** on inquiry card.

Water Conditioning. New 4-page bulletin describes and illustrates maker's water-conditioning equipment. —Penfield Mfg. Co., Inc., 19 High School St., Meriden, Conn.

Circle **576** on inquiry card.

W. S. ROCKWELL
Butterfly Valves
for Any Operating Condition
to 300 p.s.i. and 2000° F.

Minimum Pressure Drop
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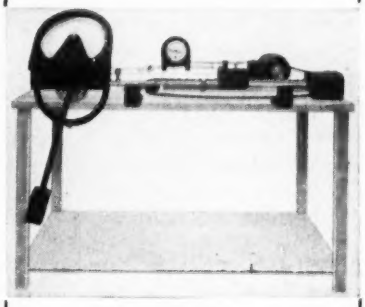

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Full 4½" dial face. Stem can be placed at any angle and case can be rotated to any readable position.

1 **Rigid Stem Dial Thermometer** tapered bulb, interchangeable with standard industrial thermometer separable socket. (As illustrated above.)

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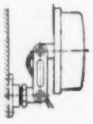

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Send for Bulletin 51-129 for details on the New Palmer Dial Thermometer.

PALMER
THERMOMETERS, INC.
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Mfrs. of Industrial Laboratory Recording and Dial Thermometers

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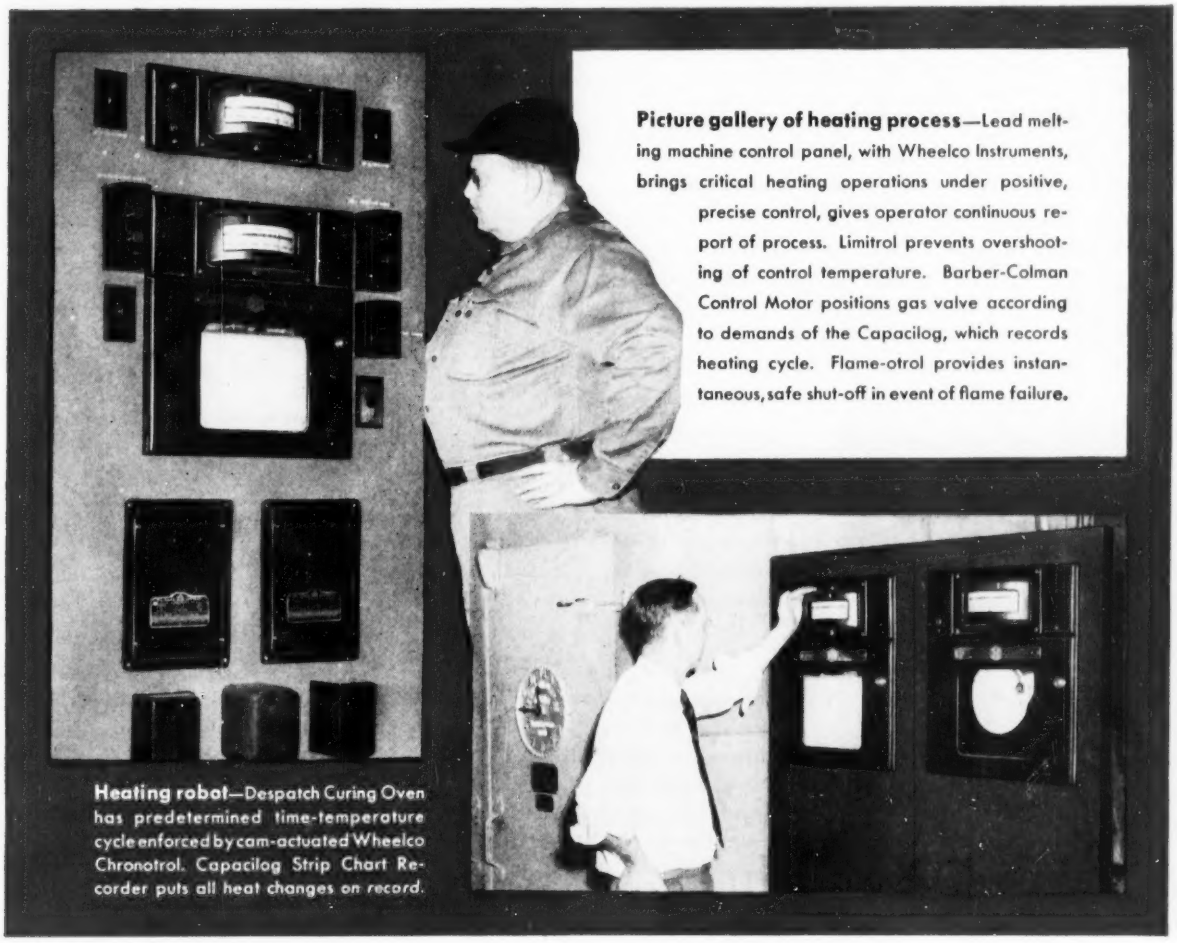
BARBER COLMAN

Wheelco Instruments

"mastermind" heating for curing and melting processes at REPUBLIC RUBBER DIV.

There are no heating blind spots in curing and melting operations at Republic Rubber Division of Lee Tire and Rubber Company. Wheelco Instruments automatically control each heating step precisely—help maintain constant, high quality production of small rubber parts and heavy insulated cable. Wheelco's Capacilog permanently records temperatures of the Despatch curing oven. Proper time-temperature cycle is enforced by a Wheelco Chronotrol, assuring product uniformity with economies in both time and labor. These are only a few of the ways Wheelco Instruments work for Republic Rubber—better see how they can work, *and save*, for you!



Picture gallery of heating process—Lead melting machine control panel, with Wheelco Instruments, brings critical heating operations under positive, precise control, gives operator continuous report of process. Limitrol prevents overshooting of control temperature. Barber-Colman Control Motor positions gas valve according to demands of the Capacilog, which records heating cycle. Flame-otrol provides instantaneous, safe shut-off in event of flame failure.

Heating robot—Despatch Curing Oven has predetermined time-temperature cycle enforced by cam-actuated Wheelco Chronotrol. Capacilog Strip Chart Recorder puts all heat changes on record.

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Gordon XACTLINE can be placed in the control circuit of any fuel-fired or electrically heated oven, furnace, kiln, injection molding machine, etc. Once installed, no adjustment or coordination with the control instrument is required regardless of size of furnace, length of heating cycle, or density of load. It can be used equally well with any existing indicating or recording standard pyrometer controller, regardless of age.

Gordon XACTLINE—a complete, factory-assembled, factory-adjusted instrument enclosed in dustproof case, ready for installation anywhere.

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4528

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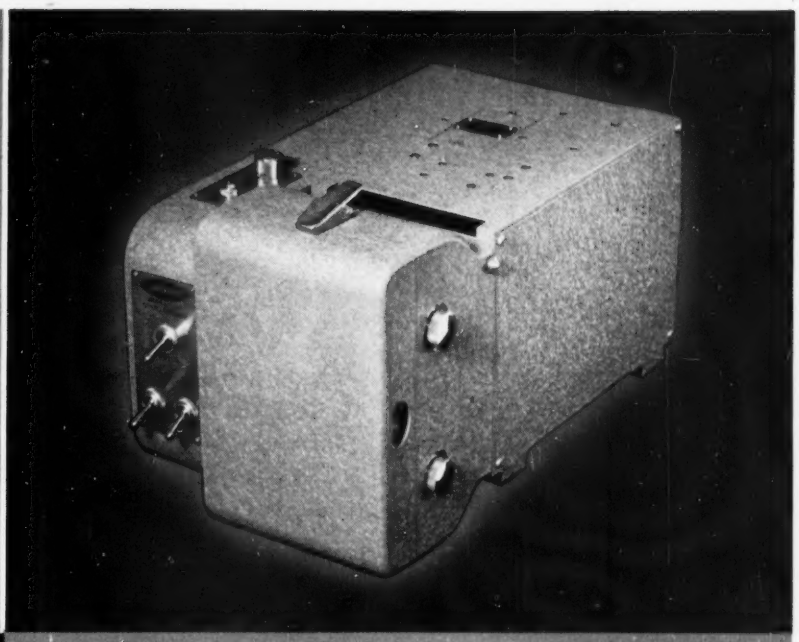
- Model 158-14 — 14-trace magnetic structure.
- Trace identification (beam-interrupter type).
- Full-width external graduated viewing screen with 1-to-1 deflection ratio with recording medium.
- Rugged design for dependable operation under high-gravity and adverse vibration conditions.
- Unexposed footage indicator.
- Easily accessible galvanometer damping-resistor board.
- Lamp burnout indicators (timing and galvanometer).
- No record movement indicator.



MIDWESTERN MODEL 580 OSCILLOGRAPH

PHYSICAL DATA:

Dimensions: 7¼" wide x 6¼" high x 12¾" long, including external knobs and controls.

Weight: 16 pounds (without shock-mounted base).

ENGINEERING DATA:

Recording Speeds: 1, 3, 6½, 13 and 32 in./sec by gear changes. Higher paper speeds up to 42 in./sec. available as optional.

Magazine Capacity: 100' x 3⅝" wide Industrial Recording Paper or equivalent.

Power Requirements: 24 volt dc at 9 amps.

Timing Lines: Precision full-paper-width at 0.01 and/or 0.1 second (0.1 lines accentuated when 0.01 lines are used) by use of governor-controlled motor driving a shutter-type timer that is not "g" sensitive.

OPTIONAL EQUIPMENT:

Spare Magazine

Shock-mounted base

Selection of number and type of galvanometers

Remote-control equipment

Record numbering

Midwestern's rugged Model 580 Oscillograph was designed for dependable operation as a flight-test instrument, although it is equally useful in other field and laboratory applications. Among its more important features are: (1) 14 channels of separate data, (2) rigid cast aluminum alloy construction, (3) full-width timing lines at 0.01 sec with 0.1 sec lines accentuated or 0.1 sec lines only, (4) shutter-type "g"-proof precision timer, (5) trace identification (beam-interrupter type), (6) record numbering. The oscillograph speeds may be varied through a wide range by a positive gear drive. All controls are placed outside the oscillograph. This instrument has a full-width viewing screen which displays galvanometer traces on a one-to-one ratio with the traces being recorded; these traces may be observed while the oscillograph is operating. Midwestern offers a wide variety of precision galvanometers for use in this oscillograph which have undamped natural frequencies up to 3500 cps.

For Complete Information and Price Quotations, Phone, Wire or Write

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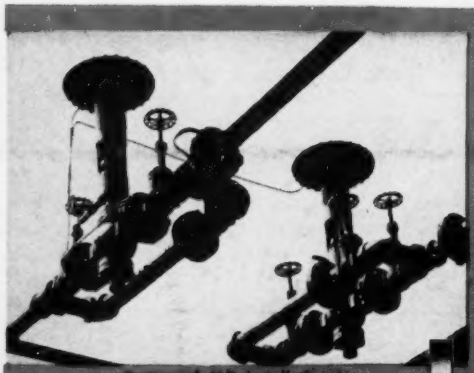
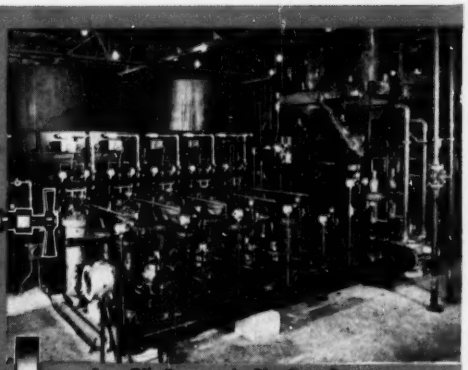
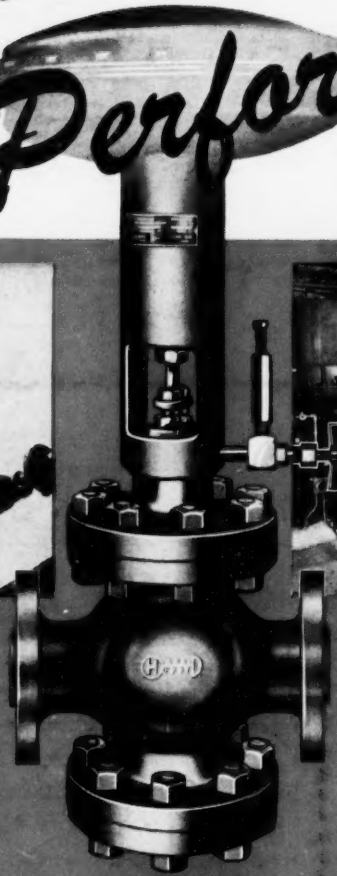


Portion of H-D installation in a Pennsylvania chemical plant.

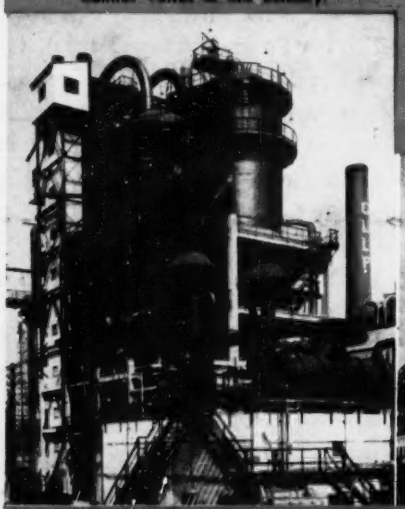


Sun Oil Company's Blending Process controlled by a battery of H-D Valves.

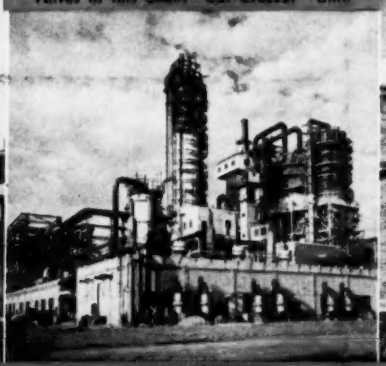


HAMMEL-DAHL CONTROL VALVES

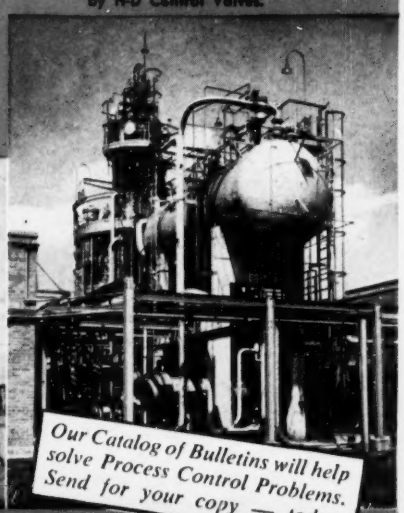
Gulf Oil Corporation uses H-D Control Valves in this Refinery.



The Texas Company installed H-D Control Valves in this Giant "Cat Cracker" Unit.



Lever Bros., Solenol Unit served by H-D Control Valves.



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